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Hydraulic Research in the United States

1962



United States Department of Commerce

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Miscellaneous Publication 245

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 (\$1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 (\$1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (Includes Titles of Papers Published in Outside Journals 1950 to 1959) (\$2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

Hydraulic Research in the United States

1962

(Including Contributions from Canadian Laboratories)

Edited by Helen K. Middleton



National Bureau of Standards Miscellaneous Publication 245

Issued October 26, 1962

FOREWORD

The information contained in this publication was compiled from reports by the various hydraulic and hydrologic laboratories in the United States and Canada. The cooperation of these agencies is greatly appreciated. The National Bureau of Standards cannot assume responsibility for the completeness of this publication. We must depend upon reporting laboratories for the completeness of the coverage of their own programs, as well as upon new laboratories engaged in hydraulics to bring their activities to our attention.

Projects are numbered chronologically, and the number once assigned is repeated for identification purposes until a project is completed. Numbers commencing with 4066 refer to projects which are reported for the first time. All projects are in active state, unless otherwise noted under (f).

The National Bureau of Standards does not maintain a file of reports or detailed information regarding the research projects reported by other organizations. Such information may be obtained from the correspondent listed under (c) or immediately following the title of the organization reporting the work. It is of course understood that any laboratory submitting reports on its work will be willing to supply information to properly qualified inquirers.

A similar bulletin, "Hydraulic Research," compiled and published by the International Association for Hydraulic Research, contains information on hydraulic research being conducted in foreign countries. This bulletin is edited by Professor H. J. Schoemaker, Director of the Hydraulic Laboratory at the Technical University of Delft, Netherlands, and Secretary of the International Association for Hydraulic Research. Copies may be obtained from the Secretary at \$6.00 each (postage included).

A. V. Astin, Director

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Key to Projects

(a) Number and title of project	(e) Description
(b) Project conducted for	(f) Present status
(c) Correspondent	(g) Results
(d) Nature of project	(h) Publications

LIST OF CONTRIBUTING LABORATORIES

ARKANSAS, UNIVERSITY OF Agricultural Expt. Station, Fayetteville, Ark. Prof. Kyle Engler, Head Agricultural Engineering Dept.	1	CORNELL UNIVERSITY Engineering Dept., Ithaca, N. Y. Mr. O. C. French, Head	22
ARKANSAS, UNIVERSITY OF Civil Engineering Dept., Fayetteville, Ark. Prof. J. R. Bissett, Acting Head	1	CORNELL UNIVERSITY School of Civil Engineering Applied Hydraulic Lab., Ithaca, N. Y. Prof. Marvin Bogema, in Charge	22
BALDWIN-LIMA-HAMILTON CORP. Hydraulic Turbine Laboratory 2929-19th St., San Francisco 10, Calif. Mr. R. M. Bacchi, Development Engineer	1	DAVID TAYLOR MODEL BASIN (see U. S. Government)	
BEACH EROSION BOARD (see U. S. GOVERNMENT)		DELAWARE, UNIVERSITY OF Dept. of Civil Engineering Fluid Mechanics Lab. Section, Newark, Del. Dr. Kurt Frey, Directing Head	23
BONNEVILLE HYDRAULIC LABORATORY (see U. S. Govt., U. S. Army Engineer District, Portland)		FLORIDA, UNIVERSITY OF Engineering and Industrial Exp. Station Coastal Engineering Lab., Gainesville, Fla.	23
BROOKLYN, POLYTECHNIC INSTITUTE OF 333 Jay Street, Brooklyn 1, New York Prof. Matthew W. Stewart, Civil Engineering	1	GEORGIA INSTITUTE OF TECHNOLOGY Hydraulics Lab., School of Civil Engineering Atlanta, Georgia Prof. C. E. Kindsvater	24
CALIFORNIA INSTITUTE OF TECHNOLOGY Engineering Division, Pasadena 4, Calif. Prof. Milton S. Plesset, Applied Mechanics	1	HARVARD UNIVERSITY Div. of Engineering and Applied Physics Cambridge, Mass. Prof. Harold A. Thomas, Jr.	25
CALIFORNIA INSTITUTE OF TECHNOLOGY Hydrodynamics Laboratory Pasadena 4, Calif.	2	IDAHO, UNIVERSITY OF Engineering Experiment Sta., Moscow, Idaho Dean Allen S. Janssen, Director	25
CALIFORNIA INSTITUTE OF TECHNOLOGY W. M. Keck Laboratory of Hydraulics and Water Resources, Pasadena 4, Calif. Dr. Vito A. Vanoni, Professor of Hydraulics	3	ILLINOIS STATE WATER SURVEY DIVISION Box 232, Urbana, Illinois Mr. William C. Ackermann, Chief.	26
CALIFORNIA, UNIVERSITY OF College of Agriculture, Davis, Calif. Mr. Robert M. Hagan, Chairman Department of Irrigation	4	ILLINOIS STATE WATERWAYS DIVISION Dept. of Public Works and Buildings 201 West Monroe St., Springfield, Ill. Mr. Thomas B. Casey, Chief Waterway Engr.	30
CALIFORNIA, UNIVERSITY OF Div. of Agricultural Sciences Los Angeles 24, Calif. Department of Irrigation and Soil Science	5	ILLINOIS, UNIVERSITY OF Dept. of Agricultural Engineering, Urbana, Ill. Dr. Frank B. Lanham, Head	30
CALIFORNIA, UNIVERSITY OF College of Engineering, Berkeley 4, Calif. Prof. J. W. Johnson, Hydraulic Engineering	6	ILLINOIS, UNIVERSITY OF Civil Engineering Dept., Urbana, Ill. Dr. V. T. Chow, Prof. Hydraulic Engineering	30
CALIFORNIA, UNIVERSITY OF Dept. of Naval Architecture, Berkeley 4, Calif. Prof. H. A. Schade, Chairman	11	ILLINOIS, UNIVERSITY OF Dept. of Theoretical and Applied Mechanics 214 Talbot Laboratory, Urbana, Ill. Prof. T. J. Dolan, Head	31
CALIFORNIA, UNIVERSITY OF Institute of Industrial Cooperation Dept. of Engineering, Los Angeles 24, Calif. Prof. J. Morley English, Director, Research	12	IOWA INSTITUTE OF HYDRAULIC RESEARCH State University of Iowa, Iowa City, Iowa Dr. Hunter Rouse, Director	32
CALIFORNIA, UNIVERSITY OF SOUTHERN Research Foundation for Cross-Connection Control, Los Angeles 7, Calif. Dr. K. C. Reynolds, Supervisor	12	IOWA STATE UNIVERSITY Dept. of Agricultural Engineering, Ames, Iowa Prof. Hobart Beresford, Head	35
CALIFORNIA, UNIVERSITY OF SOUTHERN Department of General Engineering Los Angeles 7, Calif. Professor Herbert H. Spencer	12	IOWA STATE UNIVERSITY Iowa City, Iowa (see Iowa Institute of Hydraulic Research)	7
CARNEGIE INSTITUTE OF TECHNOLOGY Dept. of Civil Engineering, Pittsburgh 13, Pa. Dr. T. E. Stelson, Head	13	JOHNS HOPKINS UNIVERSITY, THE Applied Physics Lab., Silver Spring, Md. Mr. R. E. Gibson, Director	35
COLORADO STATE UNIVERSITY Hydraulics Laboratory Civil Engineering Section, Fort Collins, Colo. Dr. A. R. Chamberlin, Chief	14	JOHNS HOPKINS UNIVERSITY, THE School of Engineering, Baltimore 18, Md. Dr. John C. Geyer, Chairman Dept. of Sanitary Engineering and Water Resources	36
COLORADO, UNIVERSITY OF Engineering Experiment Sta., Boulder, Colo. Mr. C. A. Hutchinson, Acting Director	21	KANSAS, UNIVERSITY OF Dept. of Engineering Mechanics, Lawrence, Kansas Dr. Kenneth C. Deemer, Chairman	37
CONNECTICUT, UNIVERSITY OF School of Engineering, Box U-37, Storrs, Conn. Prof. Ronald S. Brand	22	LEHIGH UNIVERSITY Department of Civil Engineering Fritz Engineering Lab., Bethlehem, Pa. Prof. W. J. Eney, Director and Head of Dept.	38

LOUISIANA STATE UNIVERSITY AND A AND M COLLEGE Agricultural Engineering Department Baton Rouge 3, La. Mr. Harold T. Barr, Head	39	OKLAHOMA STATE UNIVERSITY Agricultural Engineering Dept., Stillwater, Okla. Prof. E. W. Schroeder, Head	54
MASSACHUSETTS INSTITUTE OF TECHNOLOGY Dept. of Civil and Sanitary Engineering Cambridge 39, Mass. Dr. Arthur T. Ippen, Head, Hydrodynamics Lab.	39	OREGON STATE COLLEGE Hydraulics Lab., Dept. of Civil Engineering Corvallis, Oregon Dr. Charles E. Behlke	54
MASSACHUSETTS INSTITUTE OF TECHNOLOGY Dept. of Mechanical Engineering Cambridge 39, Mass. Prof. Ascher H. Shapiro, in Charge Fluid Mechanics Division	43	PENNSYLVANIA STATE UNIVERSITY Ordnance Research Lab., University Park, Pa. Dr. John C. Johnson, Director	54
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MICHIGAN STATE UNIVERSITY Dept. of Civil Engineering, East Lansing, Mich. Dr. Emmett M. Laursen, Associate Professor	45	PURDUE UNIVERSITY Dept. of Agronomy, Lafayette, Ind. Dr. Dale Swartzendruber	56
MICHIGAN, UNIVERSITY OF Dept. of Civil Engineering 320 W. Engineering Building Ann Arbor, Michigan Prof. E. F. Brater	46	PURDUE UNIVERSITY Chemical Engineering Dept., Lafayette, Ind. Dr. Edward M. Comings	57
MINNESOTA, UNIVERSITY OF Minneapolis, Minn. (see St. Anthony Falls Hydraulic Laboratory).		PURDUE UNIVERSITY Civil Engineering Dept., Lafayette, Ind. Prof. K. B. Woods, Head	58
MINNESOTA, UNIVERSITY OF Agricultural Experiment Station, St. Paul 1, Minn. Prof. A. J. Schwantes, Head	47	PURDUE UNIVERSITY School of Electrical Engineering, Lafayette, Ind. Dr. T. F. Jones, Head	59
MISSOURI SCHOOL OF MINES AND METALLURGY Dept. of Civil Engineering, Rolla, Missouri Dr. C. L. Wilson, Dean	47	PURDUE UNIVERSITY Jet Propulsion Center, Lafayette, Ind. Dr. Maurice J. Zucrow, Director	59
MONTANA STATE COLLEGE Agricultural Experiment Sta., Bozeman, Mont. Mr. Charles C. Bowman, Acting Head Agricultural Engineering Dept.	47	PURDUE UNIVERSITY School of Mechanical Engineering Lafayette, Ind. Dr. R. J. Grosh, Head	60
NEBRASKA, UNIVERSITY OF Hydrodynamics Laboratory Dept. of Engineering Mechanics Lincoln 8, Nebraska Dr. T. Sarpkaya	48	PURDUE UNIVERSITY School of Mech. Engrg., Automatic Control Lab. W. Lafayette, Ind. Dr. Rufus Oldenburger, Head	61
NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO. Hydraulic Laboratory Newport News, Virginia Mr. C. H. Hancock, Director	48	ROCKY MOUNTAIN HYDRAULIC LABORATORY Allenspark, Colo., Prof. C.J. Posey, Director (Winter address: State Univ. of Iowa, Iowa City, Iowa)	61
NEW YORK UNIVERSITY Dept. of Chemical Engineering, Bronx 55, N.Y. Prof. John Happel, Chairman	49	ST. ANTHONY FALLS HYDRAULIC LABORATORY University of Minnesota Miss. River at Third Ave., S.E. Minneapolis, Minn. Dr. Lorenz Straub, Director	61
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NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING University of North Carolina Department of Engineering Research, Raleigh, North Carolina Prof. N. W. Connor, Director, Engrg. Research	50	SOUTHERN METHODIST UNIVERSITY Hydraulics Laboratory, Dept. of Civil Engrg. Dallas 22, Texas Prof. I. W. Santry, Jr.	66
NORTH DAKOTA STATE UNIVERSITY Agricultural Engineering Dept., Fargo, No. Dak. Mr. W. J. Promersberger, Chairman	51	SOUTHWEST RESEARCH INSTITUTE Dept. of Mechanical Sciences San Antonio 6, Texas Dr. H. Norman Abramson, Director	66
NORTHWESTERN UNIVERSITY The Technological Institute, Evanston, Ill. Dean Harold B. Gotaas	51	STANFORD UNIVERSITY Dept. of Civil Engineering, Stanford, Calif. Prof. Ray K. Linsley, Exec. Head Hydraulic Laboratory	67
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WORCESTER POLYTECHNIC INSTITUTE Alden Hydraulic Laboratory Worcester 9, Mass. Prof. L. J. Hooper, Director	84	U. S. ARMY ENGINEER DISTRICT, PORTLAND Bonneville Hydraulic Laboratory 628 Pittock Block, Portland 5, Oregon The District Engineer	128

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Dept. of Civil Engineering
Kingston, Ontario, Canada
Dr. A. Brebner, Chairman

179 TORONTO, UNIVERSITY OF
Dept. of Mechanical Engineering
Toronto 5, Canada
Prof. G. Ross Lord, Head

HYDRAULIC RESEARCH IN THE UNITED STATES

UNIVERSITY OF ARKANSAS, Agricultural Experiment Station.

(2255) GROUND WATER, RESOURCES AND RECHARGE, IN THE RICE GROWING AREA OF ARKANSAS.

- (b) Arkansas Agricultural Experiment Station cooperative with U. S. Geological Survey and U. S. Corps of Engineers.
- (c) Prof. Kyle Engler, Head of Agricultural Engineering Dept., University of Arkansas, Fayetteville, Arkansas.
- (d) Basic and applied research.
- (e) The straight 26-inch sand-packed recharge well has been tested for one year and results have not proved completely satisfactory. Main difficulties encountered arise in duplicating test condition under field situations. The sand packed well seemed to filter out plugging material but redevelopment proved more difficult than in the gravel packed well. Separan AP-30 was tried but proved unsatisfactory for conditions as encountered in this test. A slow gravel filter has been constructed and will be tested as a means of clarifying recharge water during the winter and spring of 1960-61.
- (g) Project reports are in process of being published.

(4066) HYDRAULICS OF FURROW IRRIGATION.

- (b) Arkansas Agricultural Experiment Station.
- (c) Prof. Billy B. Bryan, Dept. Agric. Engr., Univ. of Arkansas, Fayetteville, Arkansas.
- (d) Experimental, field investigations; basic research.
- (e) Investigations of fundamental hydraulic criteria involved in flow of water in irrigated furrows (shallow flow in small, open channels). Object is to develop equations for determining (1) rate of stream advance and recession; (2) depression storage; (3) stream size-storage relationships.
- (g) The project has not developed to the point where significant reports may be made.

(4067) SURFACE DRAINAGE IN BOTTOM LAND SOILS AND TOPOGRAPHY.

- (b) Arkansas Agricultural Experiment Station.
- (c) Asst. Prof. Warren Harris, Dept. Agric. Engr., Univ. of Ark., Fayetteville, Ark.
- (d) Experimental and field investigations; applied research.
- (e) The purpose of this study is to define the physical requirements for adequate drainage of individual crop rows and of field-sized areas in the bottom land soils and topography of the Miss. River Delta. Shallow surface field ditches are the largest drainage structures considered. Findings are based on the assumption that larger drainage structures must be of a size that will not restrict drainage for undue periods of time.
- (g) Depressions and restricted outlets have been found to be the basic causes of inadequate drainage in both individual rows and in shallow surface field ditches. Shallow ditches can be designed and constructed so that with a nominal amount of maintenance, they will form only minor obstructions to mechanized farming operations.
- (h) "Row Drainage Studies in the Delta Area," by Warren Harris, Arkansas Farm Research, Vol. IX, No. 6, Nov. - Dec. 1960.
- "Surface Field Ditch Studies," by Warren Harris and James Jacks, to be published in Arkansas Farm Research, Vol. X, No. 6, Nov. - Dec. 1961.

UNIVERSITY OF ARKANSAS, Civil Engineering Dept.

(4068) TURBULENT FLOW IN POROUS MEDIA.

- (b) University of Arkansas.
- (c) Prof. John C. Ward, Assistant Professor of Civil Engineering, University of Arkansas, Fayetteville, Arkansas.
- (d) The project is an experimental verification of a theoretical equation and is basic research that has definite practical implications.
- (e) To experimentally verify a theoretical equation that applies to both laminar and turbulent flow and the corresponding transition region between these two extremes for fluid flow in porous media.
- (g) The theoretical equation has been verified by experimental data found in the literature. However, due to the somewhat limited range of this experimental data, further experimentation is being performed to verify the general application of the equation.

THE BALDWIN-LIMA-HAMILTON CORPORATION, Hydraulic Turbine Laboratory.

(4069) MODEL TESTING OF NEW BUCKETS FOR LOW RATIO IMPULSE TURBINES.

- (b) Laboratory project.
- (c) Mr. R. M. Bacchi, Development Engineer, Pelton Division, Baldwin-Lima-Hamilton Corporation, 2929 - 19th Street, San Francisco 10, California.
- (d) Experimental; applied research for design.
- (e) Several new bucket types were tested in horizontal shaft configuration with various physical arrangements at a ratio of pitch diameter to nominal jet size of approximately 12.
- (f) Completed.
- (g) Results provide data for new design and modernization programs for existing designs.

(4070) MODEL TESTING OF VERTICAL SHAFT, LOW RATIO SIX NOZZLE IMPULSE TURBINES.

- (b) Laboratory project.
- (c) Mr. R. M. Bacchi, Development Engineer Pelton Division, Baldwin-Lima-Hamilton Corp., 2929 - 19th Street, San Francisco 10, California.
- (d) Experimental; applied research for design.
- (e) Variety of wheels with different bucket sizes and types were tested in vertical shaft configuration at about 12 ratio with various combinations of housings, ceiling height and nozzle straightening vane styles.
- (f) Completed.
- (g) Results provide data for new designs.

POLYTECHNIC INSTITUTE OF BROOKLYN

(4071) DIFFUSION OF SUBMERGED JETS.

- (b) Laboratory project.
- (c) Prof. Matthew W. Stewart, Assoc. Prof. of Civil Engineering, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn 1, N. Y.
- (d) Applied research for masters thesis.
- (e) Diffusion of a horizontal water jet in a zero or low velocity body of water.
- (g) In planning stage.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Engineering Division.

(1548) SPECIAL PROBLEMS IN HYDRODYNAMICS.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. Milton S. Plesset, Calif. Inst. of Tech., Pasadena, California.
- (d) Theoretical and experimental; basic research.
- (e) Studies of cavitating and noncavitating flow; dynamic behavior of cavitation bubbles; theoretical studies of cavitation damage.
- (h) "On Cathodic Protection in Cavitation Damage," by M. S. Plesset, J. of Basic Engineering, Trans. ASME, Series D, Vol. 82, 808-820, December 1960.
"Water Waves Generated by Thin Ships," by Milton S. Plesset and T. Yao-tsu Wu, Jour. of Ship Research, Vol. 4, No. 2, 25-36, November 1960.
"Growth of Vapor Bubbles in a Rapidly Heated Liquid," by S. A. Zwick, Physics of Fluids, Vol. 3, No. 5, Sept. - Oct. 1960.
"Theory of Gas Bubble Dynamics in Oscillating Pressure Fields," by Milton S. Plesset and Din-Yu Hsieh, Phys. of Fluids, 3, No. 6, Nov.-Dec. 1960.
"Theory of Rectified Diffusion of Mass into Gas Bubbles," by Din-Yu Hsieh and Milton S. Plesset, J. Acoust. Soc. Am., 33, 2, pp. 206-215, Feb. 1961.
"Comments on the Theory of Rectified Diffusion," by Milton S. Plesset and Din-Yu Hsieh, J. of the Acoust. Soc. of Am., Vol. 33, No. 3, pp. 359-360, March 1961.
"On the Propagation of Sound in a Liquid Containing Gas Bubbles," by Din-Yu Hsieh and Milton S. Plesset, The Physics of Fluids, Vol. 4, No. 8, Aug. 1961.
"Uniform Distributions of Sound Sources on the Surface of a Rigid Sphere and Some Applications," by Robert Hickling, Calif. Inst. of Tech. Eng. Div. Rep. No. 85-18, Feb. 1961.
"Theory of the Acoustic Absorption by a Gas Bubble in a Liquid," by Din-Yu Hsieh and Milton S. Plesset, Calif. Inst. of Tech. Eng. Div. Rep. No. 85-19, Nov. 1961.

(3377) THEORETICAL STUDIES IN HYDRODYNAMICS.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. T. Y. Wu, California Institute of Technology, Pasadena, California.
- (d) Theoretical; basic research.
- (e) Studies of hydrodynamic flows with free surface phenomena; steady and unsteady flows; hydrofoil problems; principle of fish propulsion; flows through porous media.
- (h) "Swimming of a Waving Plate," by T. Y. Wu, J. Fluid Mechanics, Vol. 10, pp. 321-344, 1961. Also, Calif. Inst. of Tech. Engrg. Division Report No. 97-1, August 1960.
"A Wake Model for Free-Streamline Flow Theory: Part I. Fully and Partially Developed Wake Flows and Cavity Flows Past an Oblique Flat Plate," by T. Y. Wu, Calif. Inst. of Tech. Eng. Division Report No. 97-2, Sept. 1961.
"A Wake Model for Free-Streamline Flow Theory: Part II. Perturbation Theory for Wake Flows and Cavity Flows Past a Slightly Curved Plate," by T. Y. Wu and D. P. Wang, Calif. Inst. of Tech. Eng. Division Report No. 97-3, in press.
"Unsteady Supercavitating Flows with Various Cavity-Flow Models," by D. P. Wang and T. Y. Wu, (in preparation).

(4072) CAVITATION DAMAGE.

- (b) The International Nickel Company, Inc.
- (c) Prof. Milton S. Plesset, Calif. Inst. of Tech., Pasadena, Calif.
- (d) Theoretical and experimental; basic research.
- (e) Laboratory studies of cavitation damage.
- (h) "New Techniques for Studying Resistance to Cavitation Damage," by Milton S. Plesset,

Research Seminar on Improved Materials for Critical Applications (presented by The International Nickel Company, Inc.)
Transcript of Presentations, April 1961.
"New Technique for the Study of Cavitation Erosion," by Milton S. Plesset (in press).

(4073) STUDIES IN VENTILATING FLOWS AND VENTILATION OF HYDROFOILS.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. T. Y. Wu, Prof. A. J. Acosta, Dr. D. K. Ai, Prof. H. Spencer and T. Kiceniuk, California Institute of Technology, Pasadena, California.
- (d) Project is both theoretical and experimental; basic unclassified research.
- (e) Theoretical and experimental studies are being carried out to investigate the mechanism and scale effect associated with the ventilating flow past submerged or surface-piercing bodies and lifting surfaces. Two aspects of this phenomenon are being considered: forced ventilation in which an injected gas is responsible for the generation and maintenance of a cavity or free surface flow, and spontaneous ventilation in which a gas flow is created across a gas-liquid interface into a region that was originally occupied by liquid at lower pressure. The occurrence of the latter may result in major changes in the lift force on a hydrofoil support system, for example. Various flow configurations are being considered with special reference to the problem of scaling effects which may appear in different types of these ventilated flows.
- (g) Preliminary theoretical and experimental results have been obtained for further investigations.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Hydrodynamics Laboratory.

(2746) HYDRODYNAMICS OF SUBMERGED BODIES AND WATER WAVES.

- (b) Bureau of Weapons, Dept. of the Navy.
- (c) Prof. A. J. Acosta, T. Y. Wu and T. Kiceniuk, Hydrodynamics Laboratory, California Inst. of Technology, Pasadena, California.
- (d) Experimental and theoretical investigation.
- (e) Detailed investigations of the basic hydrodynamic phenomena concerning the water waves and the motion of submerged bodies, including the various aspects of unsteady flow, partial and supercavitating regime, wakes and turbulent mixing. Several problems under the current programs are:
(1) Supercavitating flow past a delta wing;
(2) unsteady cavitating flow past a disc and an oscillating hydrofoil; (3) simulated wave-riding dolphin; (4) the flow field measurement around a submerged hydrofoil; (5) transient capillary waves.
- (h) "Simulated Wave-riding Dolphins," by B. Perry, A. J. Acosta, T. Kiceniuk, Nature, Vol. 192, No. 4798, pp 148-150, Oct. 14, 1961.

(3378) CAVITATION IN CASCADES.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. A. J. Acosta, Hydrodynamics Lab., California Institute of Technology, Pasadena, California.
- (d) Theoretical basic unclassified research.
- (e) Study of flow through a cascade of cavitating circular arc hydrofoils. Linearized theory is used to obtain lift and drag coefficients, cavitation numbers and turning for the case of infinitely long cavities. The work is extended to consider the partial cavitating configurations.

(2748) RELATION BETWEEN TRANSPORT OF SEDIMENT AND
THE HYDRAULIC CHARACTERISTICS OF STREAMS.

- (b) Agricultural Research Service, U. S. Dept. of Agriculture.
- (c) Prof. V. A. Vanoni and Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, Calif.
- (f) Completed January 1961.
- (h) "Stationary Waves and Antidunes in Alluvial Channels," John F. Kennedy, Report KH-R-2, Calif. Inst. of Tech., Pasadena, California, January 1961.
"Further Laboratory Studies of the Roughness and Suspended Load of Alluvial Streams," John F. Kennedy, Report KH-R-3, Calif. Inst. of Tech., Pasadena, Calif., April 1961.
"On the Relation between Fall Velocities and Sieve Diameter Distributions of Sand Grains," John F. Kennedy and Robert C. Y. Koh, scheduled for publication in Journal of Geophysical Research, Dec., 1961.

(3668) FLOW IN OPEN CHANNELS WITH VARYING
ROUGHNESS.

- (b) U. S. Geological Survey.
- (c) Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, Calif.
- (d) Thesis project, partly experimental.
- (e) In natural streams, the roughness pattern (dunes, ripples, flat, etc.) is often not uniform across the bed at a given cross section. To study this problem flume experiments were conducted with beds which are rough gravel on one side of the centerline, and smooth wood on the other side. The purpose was to analyze the velocity distribution, transverse momentum exchange, and overall fluid resistance of such composite bed.
- (f) Completed June 1961.
- (h) "Exploratory Studies of Open-Channel Flow over Boundaries of Laterally Varying Roughness." R. Hugh Taylor, Report KH-R-4, Calif. Inst. of Tech., July 1961.

(3669) FLUIDIZATION OF SAND BEDS BY UPWARD FLOW.

- (b) U. S. Public Health Service (Research Grant).
- (c) Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, California.
- (d) Experimental thesis project.
- (e) When a bed of sand is lifted and expanded by an upward flow (the "quick" condition), it is really not an expanded porous medium, as previously described and analyzed by other investigations, but actually it becomes a thick suspension. The particles move freely, sometimes generating large overturning eddies in the fluid. These phenomena are being investigated in a one-foot square vertical lucite tank, 6-feet high. Studies of large expansions integrate this work with the phenomenon known as hindered settling in dilute suspensions.
- (g) Detailed measurements of concentration at various depths in a fluidized bed of uniform particles indicates that there is a considerable gradient of concentration from bottom to top, apparently caused by turbulent diffusion.

(3670) TURBULENCE AND PARTICLE ENTRAINMENT IN
SETTLING TANKS.

- (b) U. S. Public Health Service.
- (c) Prof. Vito A. Vanoni, Calif. Inst. of Tech., Pasadena, California.
- (d) Experimental research.
- (e) Flow in a settling tank is simulated by introducing water with a low turbulence level and uniform velocity into a flume 15 feet long with the bed covered by a thin layer of sediment. As the flow proceeds into the flume, a boundary layer de-

velops and becomes progressively thicker. By visual observation, the critical flow conditions are determined at various distances from the flume inlet, for which grains will be entrained.

- (g) Experiments are in progress, but no results are yet available.

(3671) EVALUATION OF FORMULAS FOR THE TRANSPORT
RATE OF SEDIMENT BY ALLUVIAL STREAMS.

- (b) Laboratory project.
- (c) Prof. Vito A. Vanoni, Calif. Inst. of Tech., Pasadena, Calif.
- (d) Analytical research using published data.
- (e) The sediment discharge calculated by several well-known formulas is compared with actual measured sediment discharges in natural streams. The results are presented as graphs of sediment discharge against water discharge.
- (h) "Lecture Notes on Sediment Transportation and Channel Stability," Vito A. Vanoni, Norman H. Brooks, and John F. Kennedy, Report KH-R-1, Calif. Inst. of Tech., January 1961.

(4074) ENERGY DISSIPATOR FOR SEWAGE FLOWING INTO
AN OCEAN OUTFALL.

- (b) Holmes and Narver-Montgomery (Consulting Engineers for City of San Diego Sewerage Project).
- (c) Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, California.
- (d) Hydraulic model investigation.
- (e) A drop structure for sewage effluent is required between the sewage treatment plant (el. 95 feet above sea level) and ocean outfall. Since discharge goes into a closed ocean outfall pipe 2.3 miles long, air entrainment must be minimized over full range of operation (flow, 60-600 cfs and head drop, 90-10 feet). Recommended solution will include a large vortex with vertical axis.

(4075) MECHANICS OF FLOW IN SAND-BED CHANNELS AT
VERY LOW RATES OF SEDIMENT TRANSPORT.

- (b) National Science Foundation.
- (c) Prof. V. A. Vanoni or N. H. Brooks, Calif. Inst. of Tech., Pasadena, California.
- (d) Experimental and theoretical research.
- (e) Investigations will be on several detailed problems in transport of sediment in streams flowing at low velocity and low transport rate. Under these conditions, it has been observed that dunes form and cause a substantial increase in the hydraulic roughness of a stream. When dunes remain during a receding flow, the critical shear stress and critical velocity for re-initiation of movement of sediment are different from the case where motion of the grains is initiated by flow over a flat bed.
- (f) Initiated end of 1961.

(4076) PRECISION TILTING FLUME.

- (b) National Science Foundation.
- (c) Prof. Vito A. Vanoni and Prof. Norman H. Brooks, Calif. Inst. of Tech., Pasadena, California.
- (d) Development of facilities.
- (e) The flume which is to be 130 feet long, 3.5 feet wide, and 1.75 feet deep will be mounted on a rigid supporting structure carried on jacks. Water will be circulated by pumps with variable speed drives for controlling the flow rate. The slope of the flume can be adjusted continuously without interrupting an experiment, up to a maximum of 2 percent. The flume system will be able to produce programmed unsteady flow and will be equipped with convenient recording equipment for observing such flows. It is designed as a general

purpose facility for studies of open channel flow problems such as sediment transportation, boundary layers, and wave propagation in shear flow.

- (g) Preliminary designs have been completed and preparation of final designs and working drawings is under way. Completion scheduled for December, 1962.

UNIVERSITY OF CALIFORNIA, College of Agriculture,
Department of Irrigation.

(21) THE MECHANICS OF WATER DROPLET AND SPRAY
FORMATION FROM SPRINKLER NOZZLES.

- (b) California Agricultural Experiment Station.
(c) Dr. J. R. Davis, Dept. of Irrigation, Univ. of California, Davis, California.
(d) Experimental; theoretical and laboratory investigation.
(e) Investigations to evaluate the causes of wave formation of the jet, to evaluate the nature of the wave system, and to determine the relation between turbulence in the nozzle and the formation of discontinuous water drops.
(g) Results include the development of the electric needle technique for describing the frequency, amplitude and wave length of the wave system. The distance from the nozzle to the point at which the jet begins to break up has been related to Weber number and Reynold's number. For smooth nozzles, Weber number appears to be the only parameter.

(23) HYDROLOGY OF IRRIGATION SUPPLIES IN
CALIFORNIA.

- (b) California Agricultural Experiment Station.
(c) Prof. R. H. Burgy and Mr. D. C. Lewis, Dept. of Irrigation, Univ. of Calif., Davis, California.
(d) Experimental and field investigation; applied research.
(e) Evaluation of the hydrologic effects of various watershed management practices is under study on several upland drainages. Diamond drilling equipment was used to install piezometers and access tubes in two mountain watersheds for evaluation of the groundwater component of water yield by radioactive tracer techniques. Lysimeters and meteorological equipment installed in an adjacent area provide continuous measurements of evapotranspiration and potential evapotranspiration.
(h) "Interception Losses from Small Trees," by H. D. Paul and R. H. Burgy, Dept. of Irrigation, Univ. of California, Davis, California. Mimeo. 20 pages, Oct. 1961.

(25) PHYSICAL AND CHEMICAL FACTORS AFFECTING SOIL
INFILTRATION RATES.

- (b) California Agricultural Experiment Station.
(c) Doctors L. D. Doneen, D. W. Henderson, J. W. Biggar and G. R. Dutt, Univ. of Calif., Davis, Calif.
(d) Theoretical and basic laboratory studies and field applied research.
(e) Water management practices for various soils have been continued in the laboratory and field. In addition, emphasis has been placed on the chemical nature of the water by establishing 60 ring infiltrometers with growing crops.
(g) The concentration and the type of mineral constituents in the waters influence the permeability of soils, particularly when changing from one quality to another, which had a marked influence on infiltration and hydraulic conductivity.
(h) "Lower San Joaquin Valley Water Quality Investigations," by L. D. Doneen, California State Dept. of Water Resources Bul. 89, Appendix C, pp. 1-154, 1960.

(1819) DRAINAGE IN RELATION TO IRRIGATION.

- (b) California Agricultural Experiment Station.
(c) Dr. J. N. Luthin and Mr. R. V. Worstell, Univ. of Calif., Davis, California.
(d) Basic and applied research.
(e) The voltage analyzer was used to study the falling water table in tile drainage. The results of the study were compared to the work of E. C. Childs and Kirkham and Gaskell as well as experimental data obtained by Luthin and Worstell. Particular attention was paid to the effect of assuming a constant drainable porosity on the falling water table. It was shown that this assumption leads to an incorrect position of the water table but does not have a significant effect on its shape. The results of the study are in press.
During the past year a tank study was conducted on the effect of the slope of a tile line on its ability to carry fine sand that has entered the cracks. Under the conditions of the experiment it was found that at a slope of 0.2 percent the sediment was transported out of the pipe and did not accumulate. It is planned to continue this experiment next year and to make a more complete investigation of the flow through clay and concrete tile. The construction of a large drainage tank (50 feet long, 10 feet high, and 3 feet wide) has been completed. Initially, it is planned to study the effect of size and spacings of perforations in buried pipe on the flow into the pipe. A comparison will be made between pipe that is not covered with gravel or fiber glass material and pipe that is covered with fiber glass material.
The possibility of using sound as a method of measuring the soil moisture content of soil is being investigated. The velocity of sound through porous media is affected by the loading of the media. It seems quite likely, therefore, that variations in soil moisture will cause variations in sound velocity because soil moisture suction is equivalent in normal loading of the soil.
In connection with our drainage and leaching studies, it was decided to try to develop a method of measuring the soil salinity in place without the necessity of taking soil samples. For this purpose the four-electrode probe was used. Extensive laboratory testing indicated that the proposed method has promise and it is currently being tried in the field at Tranquillity, California.
A method of measuring the soil hydraulic conductivity in the absence of a water table is being developed. During the past year an equation was developed that approximately describes the problem. Tests of the equation were run on a sector tank. These tests showed that the assumptions used in deriving the equation are reasonable and indicate promise for the method. A great deal more information is needed about the effect of soil moisture and soil texture on the effective capillary pressure. This information is needed for the use of the equation.
(h) "Predicted and Experimental Water Table Drawdown During Tile Drainage," by W. Brutsaert, G. S. Taylor and J. N. Luthin, Hilgardia 1961 (in press).
"Ponded Water Flow Through Layered Soils," by G. S. Taylor, R. V. Worstell and J. N. Luthin, Trans. VII Int. Cong. Soil Sci. (in press).
"The Non-Steady Water Table in Drained Land," by J. N. Luthin, Jour. Geophys. Res. 65:4221-22, 1960.
"Proposed Method of Measuring Soil Hydraulic Conductivity in Situ," by J. N. Luthin, Nature (in press).

(3866) HYDRAULICS OF SURFACE IRRIGATION SYSTEMS.

- (b) California Agricultural Experiment Station.
- (c) Dr. J. R. Davis, Department of Irrigation, University of California, Davis, Calif.
- (d) Experimental; laboratory and field investigation.
- (e) Rational approaches to defining the flow of water in vegetative channels, dimensional analyses and model studies of rate of water advance in borders. Evaluations of criteria for design of tail water return systems, measurement of flow in small irrigation streams, and evaluation of irrigation efficiency concepts.
- (g) A method of determining flow rates in irrigation furrows with simple, inexpensive equipment was found to be fairly accurate but additional refinements are necessary. The flume studies of flow through vegetation is underway and preliminary analyses of data have been made for alfalfa and clover.
- (h) "Concepts on Design of Border Irrigation Systems," by John R. Davis, Proc. of the ARS-SCS Research Application Workshop on Hydraulics of Surface Irrigation, Feb. 9-10, 1960, ARS 41-43, Oct. 1960.
"Estimating Rate of Advance for Irrigation Furrows," by John R. Davis, Proc. of the ARS-SCS Research Application Workshop on Hydraulics of Surface Irrigation, Feb. 9-10, 1960, ARS 41-43, Oct. 1960. Pages 67-86.
"Estimating Rate of Advance for Irrigation Furrows," by John R. Davis, Trans. ASAE 4:52-54, 57, 1961.

(4086) MISCIBLE AND IMMISCIBLE FLUID DIS-PLACEMENTS IN RELATION TO SOLUTE MOVEMENT IN SOIL AND OTHER POROUS MATERIAL.

- (b) California Agricultural Experiment Station.
- (c) Doctors J. W. Biggar and D. R. Nielsen, Dept. of Irrigation, Univ. of California, Davis, California.
- (d) Theoretical and experimental; basic and applied.
- (e) The simultaneous transport of fluids and solutes through porous media is under investigation. The mixing and spreading of the fluids in the medium, the interaction of the fluids with each other and the medium have been studied. The work will help define the nature of the porous structure of materials, and the coupling between velocity and diffusion in the dispersion process. Leaching phenomena, disposal of industrial and radioactive wastes, and the movement of pesticides in soil water depend upon the dispersion process.
- (g) Mathematical models proposed to date are inadequate to describe miscible displacement in soils and other porous materials. Coupling between velocity and diffusion has been observed.
- (h) "Diffusion Effects in Miscible Displacement Occurring in Saturated and Unsaturated Porous Materials," by J. W. Biggar, and D. R. Nielsen, Jour. Geophys. Res. 65:2887-2895, 1960.
"Miscible Displacement in Soils: I. Experimental Information," by D. R. Nielsen, and J. W. Biggar, Soil Sci. Soc. Amer. Proc. 25:1-5, 1961.
"Miscible Displacement in Porous Materials," by J. W. Biggar, and D. R. Nielsen, Jour. Soil Sci. 12:188-197, 1961.
"Measuring Movements of Soil Amendments Made Possible by New Technique," by D. R. Nielsen, and J. W. Biggar, California Agric. 15(4): 7, 1961.

(4087) DYNAMIC PROJECT PLANNING.

- (b) California Agricultural Experiment Station.
- (c) Dr. V. H. Scott, Department of Irrigation, University of California, Davis, California.
- (d) Developmental design.
- (e) This study is to develop an approach to the

engineering aspects of project planning particularly adaptable for such areas where (1) water requirements whether for irrigation or other uses are supplied through pumping from wells, and (2) where problems of increased cost of pumping due to lowering the water wells, deterioration of water quality, and/or reduction in yield of wells due to depletion of available ground water supply occur. To meet these problems, a technique of project planning is developed involving flexibility, adaptability to changes in time, utilization of all of the available water supply, and additional data as it becomes available during the early years of operation of the initial stages of a project. Such a project planning approach would be useful to water development planners working under conditions of crude hydrologic data, unpredictable future water requirements, and limited availability of funds.

- (g) Detailed analysis has shown that dynamic project planning is a satisfactory engineering technique when applied to situations where development of water facilities is undertaken for presently unused water supplies in areas with a ground water deficiency. The projects that result from applying such a technique have sound engineering basis and would be more economical than conventionally designed one-stage projects.
- (h) "Dynamic Project Planning Through Integrating Multi-Stage Ground Water Development and Controlled Irrigation Water Use," Salim W. Macksoud, Doctor of Engineering Thesis, January 1962.

(4088) IRRROTATIONAL FLOW OVER A VERTICAL, SHARP-CRESTED WEIR.

- (b) California Agricultural Experiment Station.
- (c) Prof. Theodor S. Strelkoff, Acting Assistant Professor, Dept. of Irrigation, Univ. of California, Davis, California.
- (d) Theoretical, basic research, in part for doctoral dissertation.
- (e) Part of a general study of rapidly varied flow in open channels by methods of potential flow theory, the weir investigation considers the two-dimensional flow in the complex potential W-plane to result from an assumed distribution of vorticity in an auxiliary plane derived from the W-plane by conformal transformation. The resulting non-linear integral equation is solved by trial for the nappe profile and discharge coefficient. The treatment involves no approximations or linearizations.
- (g) Approximate nappe profiles and discharge coefficients obtained for weirs of head-to-height ratio, $h/w = 0.14, 1.15, 2.11, 4.36, 10.30$.
- (h) "Irrrotational Flow Over Weirs," by Theodor S. Strelkoff, A Ph.D. Dissertation, Dept. of Mechanics and Hydraulics, Graduate College of the State University of Iowa. 41 pages. June 1962.

UNIVERSITY OF CALIFORNIA, Division of Agricultural Sciences, Department of Irrigation and Soil Science.

Inquiries concerning the following projects should be addressed to Professor A. F. Pillsbury, Department of Irrigation and Soil Science, University of California, Los Angeles 24, California.

(27) HYDROLOGY OF WATER SUPPLIES IN CALIFORNIA.

- (b) Laboratory project cooperative with Pacific Southwest Forest and Range Experiment Sta., USFS, and with College of Engrg., Univ. of Calif. Los Angeles; coordinated with work of Dept. of Irrigation, Univ. of Calif., Davis, California.
- (d) Experimental; applied research.
- (e) Work now concerned with: (1) Subsurface

movement of moisture; (2) surface treatments affecting infiltration of precipitation; and (3) detention of precipitation by surface litter and effect upon infiltration.

- (g) Wettability of a soil is related to the liquid-solid contact angle. Techniques were developed by which it is possible to determine the contact angle of sands and other soils. Wettability affects water entry rates, particularly with a dry soil; it affects capillary rise, and evaporation when the soil surface is not saturated. Saturated hydraulic conductivity is not affected by contact angle. Wetting agents decrease contact angle and capillary force. In situations of high contact angle the net effect of wetting agents is to improve water entry into soil. Leachate from several types of chaparral and coniferous forest litter was found to make soils less wettable. Certain litters, because of poor wettability, exert a thatch effect - tend to shed precipitation. Certain aqueous resinous spray solutions have been evaluated in the laboratory as a means of modifying and partially controlling water entry into soil. They can stabilize surface aggregation, thus affecting slaking, raindrop impact dispersion, and erosion. Field evaluation awaits rainfall. Litter detention, as a process increasing water intake into soil, has been further evaluated, but data are not yet complete.
- (h) "Wetting Agents," J. Letey, R. E. Pelishek, and J. F. Osborn. Calif. Agric. v. 15, no. 10, pp. 8-9. 1961.

(1058) SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION.

- (b) Laboratory project, cooperative with Dept. of Soils and Plant Nutrition, Univ. of Calif., Riverside, Calif.
- (d) Continuing laboratory and field studies.
- (e) Work concerned with following wetting front downward with neutron moisture probe when soil is being wet from the top has been completed and published. Use of density probe now being evaluated.
- (g) "Infiltration Measurement With the Neutron Moisture Probe," J. Letey, E. Hsia, R. E. Pelishek, and J. F. Osborn, Soil Science 91: 77-83, 1961.

(1303) HYDRAULIC CHARACTERISTICS OF IRRIGATION DISTRIBUTION SYSTEMS.

- (b) Laboratory project, cooperative with College of Engrg., Univ. of Calif., Los Angeles 24, California.
- (d) Basic and applied research.
- (e) Graduate student now working with model low pressure pipe system to study hydraulic transients occurring with automatic operation.
- (f) Work being summarized.

(2504) DYNAMICS OF SOIL WATER FLOW TOWARDS AND INTO SUBSURFACE DRAINAGE FACILITIES.

- (b) Laboratory project, cooperative with College of Engrg., Univ. of Calif., Los Angeles 24, California.
- (d) Experimental; applied research.
- (e) Present work concerns (1) Reliability of spot techniques for determination of hydraulic conductivity; (2) relation of water table recession to theory, (3) drainage simulation in shallow soils; relating water table height to drain discharge; (4) drainage simulation in layered soils; and (5) criteria for factors contributing to excessive soil-water.
- (h) Several manuscripts in preparation. Will be reported next year.

UNIVERSITY OF CALIFORNIA, College of Engineering, Hydraulic Laboratory.

Inquiries concerning the following projects, except when otherwise indicated, should be addressed to Prof. J. W. Johnson, Dept. of Engineering, Hydraulic Laboratory, Hesse Hall, University of California, Berkeley 4, California.

(40) FLOW AND HEAT TRANSFER CHARACTERISTICS OF GAS-SOLIDS MIXTURES.

- (b) Laboratory project.
- (c) Prof. C. L. Tien, Asst. Prof. of Mech. Engrg, Univ. of Calif., Berkeley, Calif.
- (d) Theoretical and experimental (basic and applied research).
- (e) The pressure drop and heat transfer characteristics of gas-solids mixtures have been investigated by adding glass powders and lead powders of 30 microns and 200 microns in size to air streams flowing turbulently up a vertical tube. The solids-to-gas gravimetric loading ratios ranged from zero to approximately ten. Heat was transferred to the air-solids mixtures from the uniformly heated tube wall. The air rate was kept constant at Reynolds numbers of 15,000 and 30,000. Analytical studies have been made but were not quite successful.
- (g) Experimental results showed that the pressure gradients far down the tube approached a constant value, which was a monotonically increasing function of the loading ratio. Significant effect of the particle size on the pressure gradients was observed. The thermal entrance length increased with a decrease in the particle size and an increase in the loading ratio. The asymptotic Nusselt number decreased to a minimum and then increased as the loading ratio was increased. The decrease in Nusselt number was much larger for lead particles than for glass particles.
- (h) "Comparison of the Heat Transfer Characteristics of Air-Glass and Air-Lead Mixtures in Turbulent Pipe Flow," by V. Quan, M.S. Thesis in Mechanical Engineering, Univ. of Calif. Library, Berkeley, California.
- "Heat Transfer Characteristics of Air-Solids Flow in the Thermal Entrance Region of a Vertical Pipe," by W. F. Schmidt, M.S. Thesis in Mechanical Engineering, University of California Library, Berkeley, California.

(529) SAND SOURCES RESEARCH.

- (b) Beach Erosion Board, Department of the Army, Washington, D. C.
- (c) Mr. Parker D. Trask, Dept. of Mineral Tech. and Hydraulic Research Laboratory, Univ. of California, Berkeley, California.
- (d) Experimental; theoretical and field observations.
- (e) Purpose of this project is to study origin and movement of sand on beaches in vicinity of San Francisco and along the coast north of the Russian River. The project consists of periodic measurements of beach profiles, and mechanical, mineralogical and radioactive analyses of samples of sand. The project thus supplies basic data on the regimen of Northern California Beaches and gives information on the pattern of movement of sand on the beaches. Such information is desirable for effective measures for harbor control and beach erosion.
- (g) Beaches in vicinity of San Francisco advance and retreat 50 to 100 from one season to another. Grain size of beaches in northern California ranges from 200 to 1000 microns. The drift is variable.
- (h) "Beaches near San Francisco, California, 1957-1958," by P. D. Trask and D. T. Snow, Univ. of Calif. Inst. Engineering Research, Series 14, Issue 23, 90 pages, October 1961.

(1554) SEA WATER CONVERSION RESEARCH.

- (b) State of California.
- (c) Prof. Everett D. Howe, Director Sea Water Conversion Laboratory, University of Calif., 1301 South 46th Street, Richmond, California.
- (d) Experimental, theoretical, field investigation and pilot plant; basic research, applied research, design, and operation.
- (e) The purpose of this project is to discover whether there is available any method for the large-scale, low-cost demineralization of sea water. The project includes a number of investigations, of which the following have been active during 1960-61: (1) Multiple effect rotating evaporator; (2) evaporation by immiscible fluid heat transfer; (3) vacuum flash distillation (low temperature difference method); (4) solar distillation; (5) electrodialysis tests; (6) freeze-separation; (7) ion exchange; (8) biological studies; (9) capillary control of vapor transfer gaps; (10) reverse osmosis pilot plant; (11) thermodynamic and economic analysis; (12) experimental heat transfer studies; (13) properties of sea water; and (14) fundamental studies of corrosion processes. Investigations are being carried on both at Berkeley and at Los Angeles.
- (g) Detailed results may be obtained from the progress reports and publications listed under (h) below. This project has been active since 1951-52 and previous summaries have listed all reports prior to July 1960.
- (h) The following reports and publications have been issued during the period since July 1960 and summarize the work to date:
UNIVERSITY OF CALIFORNIA AT LOS ANGELES:*
"Sea Water Demineralization by Means of a Semipermeable Membrane," by S. Loeb and S. Sourirajan, Report No. 60-60, July 1960.
"The System Water-Sodium Chloride at Elevated Temperatures and Pressures," by S. Sourirajan and G. C. Kennedy, Report No. 60-77, August 1960.
"Saline Water Demineralization--A Review and Bibliography," by J. W. McCutchan, Sept. 1961.

UNIVERSITY OF CALIFORNIA AT BERKELEY:**
"Berkeley Progress Report for the Year Ending June 30, 1961," Institute of Engineering Research Series 75, Issue 24, August 1961.
"Heat of Concentration and Boiling Point Elevation of Sea Water," by K. J. Nabavian and L. A. Bromley, A.C.S. Advances in Chem. Series 27, pp. 21-26, 1960.
"Saline Water Conversion by Multiple Effect Rotating Evaporator," by R. L. Clark and L. A. Bromley, Chemical Engineering Progress, Vol. 57, No. 1, pp. 64-70, January 1961.
"Optimization and Cost Analysis of Light Water Moderated Reactors for Process Heat," by L. M. Grossman et al, Institute of Engineering Research Series 164, Issue 1, Oct. 1960.
"Electrodialysis Process May Solve Sea Water Demineralization Problem," by P. M. Rapier, Engineering and Mining Journal, Dec. 1960.
*Requests for copies should be directed to: Institute of Industrial Cooperation, Dept. of Engineering, Univ. of California, Los Angeles, California.
**Requests for copies should be directed to: Sea Water Conversion Laboratory, Univ. of Calif., 1301 South 46th St., Richmond, Calif.

(1823) THE MECHANICS OF BOTTOM SEDIMENT MOVEMENT WITH OSCILLATORY WAVES.

- (b) Beach Erosion Board.
- (d) Experimental, basic research.
- (e) To obtain experimental information on the criteria for initial and general movement of bottom sediment by wave action. Prototype conditions of the relative motion of water and bed were simulated by use of an oscillating plate in still water.
- (g) A theoretical solution has been found for the turbulent boundary layer flow along an oscillating surface and was empirically checked for the smooth bottom. A solution

has been found for the rough wall, but must be checked for various different types of roughness. The theoretical solution does not permit the determination of the bottom shear and may be unsatisfactory for this reason. It is intended to determine the dynamic lift and drag on the individual grain as a function of the local Reynolds Number obtained from the theoretical velocity profile.

(2062) STRESS-STRAIN RELATIONSHIPS FOR SHEAR IN SAND-CLAY-WATER MIXTURES.

- (b) Land Locomotion Laboratory, Detroit Arsenal, Ordnance Corp., U. S. Army.
- (c) Dr. Parker D. Trask, Hydraulic Laboratory, Hesse Hall, Univ. of Calif., Berkeley, California.
- (d) Experimental; basic research.
- (e) Stress-strain measurements are procured by means of plungers of given diameters, which are pressed into the sediment mixtures at a constant strain rate during which the stress is recorded by a system of strain gauges attached to a proving ring that is deformed as the plunger enters the sediment. The stress-strain relations are computed in terms of M. G. Bekker's coefficients and related to the composition of the mixtures.
- (f) Completed December 31, 1960.
- (g) The strength parameters proved to be related to the variables studied, namely water content, clay type, clay-clastic ratio and median diameter. Clay type is probably most important in determining strength which increases with increasing base exchange capacity of the clay, with decreasing grain size of admixed material, with increasing clay-sand ratio and decreasing water content. Tests on one illitic prototype soil showed that mineralogically identical soils may possess different strengths.
- (h) "Effect of Grain Size on Strength of Mixtures of Clay, Sand, and Water," by P. D. Trask, Bull. Geol. Soc. Amer., Vol. 70, 1959, p. 569-580.
"Effect of Clay Content on Strength of Sediments," by P. D. Trask, and J. E. H. Close, Coastal Engineering, Vol. 6, (1958) p. 827-843.
"Pressure-Sinkage Tests on Mixtures of Kaolin and Illite with Clastic Silt," by P. D. Trask and H. Klehn, Univ. of Calif., Inst. of Eng. Res. Report, Series 116, Issue 4, Sept. 1958, 13 p., 39 fig.
"Pressure-Sinkage Tests on Mixtures of Clay and Clay with Sand of Varying Grain Size," by P. D. Trask and H. Klehn, Univ. of Calif., Inst. of Eng. Res. Report, Series 116, Issue 5, Jan. 1959, 16 p., 28 fig.
"Geologic Causes of Strength in Soils," by P. D. Trask and R. E. Skjei, Univ. of Calif., Inst. of Eng. Res. Report, Series 77, Issue 7, March 1958, 43 p., 9 fig.
"Pressure-Sinkage Tests on Different Types of Soils," by P. D. Trask and R. E. Skjei, Univ. of Calif., Inst. of Eng. Res. Report, Series 116, Issue 1, May 1958, 13 p., 17 fig.
"Pressure-Sinkage Tests on Two Montmorillonite Soils," by P. D. Trask and R. E. Skjei, Univ. of Calif., Inst. of Eng. Res. Report, Series 116, Issue 2, May 1958, 7 p., 10 fig.
"Pressure-Sinkage Tests on Mixtures of Montmorillonite and Clastic Silt," by P. D. Trask, and R. E. Skjei, Univ. of Calif., Inst. of Eng. Res. Report, Series 116, Issue 3, July 1958, 25 p., 15 fig.
"Pressure-Sinkage Tests on a Natural Clay Soil from Sonoma Slough, California," by P. D. Trask and D. T. Snow, Univ. of Calif., Inst. Eng. Res. Report, Series 116, Issue 6, Dec. 1960, 34 p., 43 fig.

(2261) WAVE REFRACTION RESEARCH.

- (b) Beach Erosion Board, Dept. of Army, Wash. D. C.
- (d) Experimental basic research.
- (e) Laboratory studies are being made of the refraction and some (diffraction and reflection) phenomena of water waves. Special attention is being given to the "Mach stem" phenomenon.
- (g) In shallow water the velocity of a water gravity wave depends upon the depth of water as well as upon the length of the wave. When it travels in shoaling water it bends. This refraction changes the wave height and direction. Powerful graphical and analytical tools are available for use by the engineers; however, there is an almost complete lack of evidence as to their accuracy. The purpose of this contract has been to perform laboratory experiments to check the validity of the techniques used in practice. The first series of tests were performed in a ripple tank; these showed that the techniques were fairly reliable from a practical standpoint. A series of tests were made in a model basin 150 feet by 64 feet by 2 1/2 feet deep. The results of these tests have been published. Tests have been conducted on the formation of secondary wave crests as periodic waves pass into shoal water, and the results have been found to compare favorably with theory. Studies have been made of the non-reflecting characteristics of waves incident to a steep slope, large plane angle shore, and the results presented in a report. Additional studies have been made of the "Mach stem" phenomenon in the presence of a curved, and a wavy vertical impervious wall, and in the presence of a sloped pervious wall. Studies are being made of the refraction and short-crested wind generated waves in the laboratory.
- (h) "Higher Approximations to Nonlinear Water Waves and the Limiting Height of Cnoidal, Solitary, and Stokes' Waves," by E. V. Laitone, Univ. of Calif., IER, Tech. Rept. 89-6, March 1961.

(2265) FORCES ON ACCELERATED CYLINDERS.

- (b) Laboratory project.
- (c) Prof. A. D. K. Laird, 109 Mechanics Bldg., Univ. of California, Berkeley 4, Calif.
- (d) Experimental; basic research.
- (e) Measurement of drag coefficients and flow configurations about cylinders during accelerated motion in fluids as related to wave forces as cylinders.
- (h) "Water Eddy Forces on Oscillating Cylinders," A. D. K. Laird, C. A. Johnson, and R. W. Walker, Journal Hydraulics Div., Proc. ASCE, Vol. 86, HY 9, Nov. 1960. "Eddy Forces on Rigid Cylinders," A. D. K. Laird, Journal Waterways and Harbors Div., Proc. ASCE. (in press).

(2505) EFFECT OF SEDIMENT DISTRIBUTION IN STREAM CHANNELS.

- (b) University project.
- (d) Experimental; basic research.
- (e) Alluvial flows in channels with artificially secured banks are studied systematically for their tendency to meander as expressed by the development of alternate bars. It is the aim of this study to develop criteria for stability.
- (f) Experimental work concluded.
- (g) The important parameters seem to be the Froude's number, the depth-width ratio and the size and uniformity of the bed sediment. The uneven distribution of friction between banks and bed is of prime importance.
- (h) "A Study on Meandering and other Bed Patterns in Straight Alluvial Channels," Hsieh W. Shen, Ph.D. Thesis, University of California, Berkeley 4, Calif. Jan. 1961.

(2753) HYDRAULIC BREAKWATER.

- (b) Office of Naval Research, Dept. of the Navy.
- (d) Experimental; applied research.
- (e) Determination by model tests of the mechanisms by which hydraulic breakwaters dampen water gravity waves.
- (f) Completed.
- (g) Three dimensional tests in a model basin show that the effect of wave refraction due to the currents generated by the hydraulic breakwater is of primary importance. For certain conditions the area in the lee of the breakwater can be made to be almost free of waves, while for other conditions the waves behind the breakwater will be higher than if there were no hydraulic breakwater in operation. A series of model sizes have been used and a definite scale effect observed. Tests have been completed in connection with the measurement of the currents generated by the jets and then the effect of the currents on the waves, the purpose being to find out in which portion of the mechanism the scale effect occurs. It was found that the scale effect occurred in the orifice. The results have been published. Tests have been completed on the effect of hydraulic breakwaters on wind generated waves, and it was found that the short period components of such a wave system were damped, allowing the long period wave components to get past the breakwater.
- (h) "Attenuation of Wind Waves by a Hydraulic Breakwater," by John A. Williams and R. L. Wiegel, Univ. of Calif., IER, Tech. Rept. 104-12, December 1961.

(2755) DEVELOPMENT OF METHODS TO TRACE SEDIMENTS USING RADIOACTIVE MATERIALS.

- (b) Corps of Engineers, U. S. Army.
- (c) Prof. H. A. Einstein, Univ. of California, Berkeley 4, Calif.
- (d) Experimental; theoretical, and field.
- (e) Radioactive materials were sought which could be permanently attached to sediment grains from the sand to the clay sizes. Instrumentation was developed by which tagged sediments could be observed in prototype water courses, particularly in the San Francisco Bay.
- (f) Completed.
- (g) Scandium-46 and gold-198 were found to be the best suited materials. Instrumentation for field detection of radioactivity was developed. Four field tests in San Francisco Bay were completed and analyzed. These tests show that clayey sediments are transported in salt water in general suspension and are deposited in stable form from water flowing at less than two feet per second average velocities.
- (h) "Third Annual Progress Report on the Silt Transport Studies Utilizing Radioisotopes." "An Underwater Scintillation Detector for Gamma Emitters," 25 pp. "Methods for Tracing Estuarial Sediment Transport Processes," 57 pp.

(3020) BOUNDARY LAYER FRICTION IN THE DOLPHIN.

- (b) Laboratory Project.
- (d) Experimental; basic.
- (e) Purpose is to elicit whether there is an anomaly in skin friction of dolphins.
- (f) Completed.
- (g) Observations of four large groups of dolphins suggest that they are able to swim at a sustained speed of 14 to 18 knots. The blackfish are able to maintain about 22 knots and one killer whale seemed able to swim somewhat faster. This implies that the apparent coefficient of surface friction remains approximately constant for dolphins from 6 to 22 feet long, as is the case for rigid bodies; but on the basis of probable muscle power, it is only 1/8 the value for rigid bodies.

- (h) "Sustained Swimming Speed of Dolphins," Carl L. Johannessen and J. A. Harder, Science, v 132, no. 3439, pp. 1550-1551, Nov. 25, 1960.
- (3022) FLOATING BREAKWATER.
- (b) U. S. Navy Civil Engineering Laboratory.
 - (d) Analytical and experimental; applied research.
 - (e) Analytical and experimental studies of new concepts of floating breakwaters.
 - (f) Completed.
 - (g) Several new concepts have been investigated. One of these systems consisted of a series of long plastic tubes (slightly buoyant) connected side by side and filled with water. The effectiveness of the system was remarkable for wave lengths of the order of one-half the tube length, or less. Additional work has been done with large plastic bags filled with water with the same results. Small scale laboratory studies have been completed, including the measurement of forces in the mooring lines. Medium scale tests in San Francisco Bay have been completed.
 - (h) "Floating Breakwater Survey: Final Report," by R. L. Wiegel, H. W. Shen, and J. D. Cumming, Univ. of Calif., IER, Tech. Rept. 140-6, June 1961.
- (3382) FLUME STUDY ON THE TRANSPORT OF ESTUARIAL SEDIMENT.
- (b) Corps of Engineers, U. S. Army.
 - (c) Prof. H. A. Einstein, Univ. of Calif., Berkeley, California.
 - (d) Experimental.
 - (e) Motion of estuarial sediments in saline water is studied under controlled laboratory conditions. Both flumes and settling vessels are used. The viscosity, settling, and composition of sediment-water mixtures are also studied to understand the relationships between the properties of the sediment and its behavior in flowing salt water.
 - (h) Final report in preparation.
- (3384) SAND MOVEMENT BY WIND.
- (b) Beach Erosion Board and National Science Foundation.
 - (d) Experimental.
 - (e) To develop a trap and auxiliary equipment for field measurements of the rate of sand movement by wind action. Some field experiments also have been conducted. A reconnaissance of the coastal dunes of California has been completed to appraise the conditions under which dunes occur.
 - (h) "A General Reconnaissance of Coastal Dunes of California," by Ronald P. Zeller. Lab. Report.
- (3385) ELECTRIC FLOOD MODEL.
- (b) U. S. Corps Engineers, Kansas City Dist.
 - (d) Experimental; design and development.
 - (e) Using analog model techniques a simulator for the Kansas River and its tributaries is being developed. Purpose is to provide a rapid and convenient means of estimating the effects of reservoir operation and rainfall distribution on flood stages. All pertinent hydraulic variables will be under operator's control, and a flood routing procedure completed each 1/60 second.
 - (h) "Analog Models for Flood Control Systems," J. A. Harder, to appear in ASCE Hydraulics Journal, Dec. 1961 or Jan. 1962.
- (3386) SUBSURFACE SALINITY.
- (b) Laboratory project.
 - (d) Analytical and experimental; basic research.
 - (e) This investigation is concerned with the dynamics of the fresh-salt water interface in flow through porous media. Effects of non-steady flows and dispersion will be considered.
- (g) Experimental measurements in a parallel plate model are being made for drainage of underlying saline water in irrigated land.
 - (h) "On the Tensor Form of Dispersion in Porous Media," by J. Bear, Journal of Geophysical Research, vol. 66, pp. 1185-1197, 1961.
 - "Some Experiments in Dispersion," by J. Bear, Journal of Geophysical Research, vol. 66, pp. 2455-2467, 1961.
- (3672) WALNUT CREEK STABILIZATION.
- (b) North Walnut Creek Emergency Flood Control District.
 - (d) Experimental; for design.
 - (e) Model tests of structures to distribute evenly the flow through a compound bend with strong curvatures.
 - (f) Concluded.
 - (g) A satisfactory performance was achieved by observing the eroding effect of the flow and providing the unstable sections with rip-rap protection.
 - (h) "Model Study of North Walnut Creek Channel," by G. Kalkanis, I.E.R. Series No. 167, Issue 1.
- (3673) JET PUMP FOR SEDIMENT.
- (b) Pacific Coast Engineering Co.
 - (d) Experimental; for design.
 - (e) The use of a jet pump as a booster pump at the end of the ladder of a suction dredge is studied.
 - (f) Initial design study completed. Investigation continuing on sand erosion effects.
 - (g) Erosion rates have been substantially reduced by design modifications without sacrificing sand pumping performance.
- (3674) INVESTIGATIONS OF BOUNDARY LAYERS ALONG FLUID INTERFACES.
- (b) National Science Foundation.
 - (d) Experimental; basic research.
 - (e) To investigate the possibility of reducing friction by artificially increasing the stability of the flow.
 - (g) An extensive survey of the literature on the subject has been completed. Experimental studies have been made of the instability of the air-water interface with the air moving over the water and with an air-water temperature difference. Measurements of the pressure and velocity fluctuations in the air flow above the waves have been made. In order to permit the simultaneous measurement of several variables in a form that will facilitate their correlation, a digital data recording system is being developed. It records 8 channels with a precision of 10 bits on magnetic tape in a format compatible with the IBM 704 and at rates up to 7,500 samples per second.
- (3675) CLAY TRANSPORT.
- (b) National Science Foundation.
 - (d) Experimental and theoretical; basic research.
 - (e) A continuation and generalization of (3382) to various types of clays. The effect of flocculation and concentration of clay on flows, and the deposition and scour of these sediments are studied systematically.
- (3676) ARTIFICIAL RECHARGE OF GROUND WATER.
- (b) Laboratory project.
 - (d) Analytical and experimental; basic research.
 - (e) This investigation is concerned with the unsteady flow of water from recharge areas into homogeneous and non-homogeneous

- (g) aquifers. Solutions of the general infiltration equation have been obtained for selected boundary conditions. Experimental measurements in a translucent model have been made of unsteady flows from recharge areas percolating to impermeable sub-surface layers. A report is in preparation.
- (3677) ANNULAR NOZZLE GROUND EFFECT MACHINE.
- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. R. L. Wiegell, Dept. of Civil Engrg., Univ. of Calif., Berkeley, California.
- (d) Experimental; applied research.
- (e) Airborne vehicles supported by annular jets have a lift considerably in excess of that due to the jet momentum when operating in a region close to the ground. The dynamic lift, bending moment, wave resistance, base pressures, and intake pressures are being measured for such a vehicle operating over both calm water and water with surface gravity waves present.
- (3678) OCEAN SEWER OUTFALLS.
- (b) U. S. Public Health Service.
- (d) Basic research.
- (e) This study is concerned with the various phenomena involved in the diffusion of sewage at the discharge end of an ocean sewer outfall.
- (g) Phases investigated to date have involved mixing resulting from jet action and surface wind waves. The effects of wind and waves on surface dispersion have been studied in a laboratory wind-wave flume. Measurements of the shape of the dispersion plume have been obtained under various wind and wave conditions, and the influence of some of the wave characteristics on the eddy diffusion coefficient has been noted.
- (h) "Jet Discharge into a Fluid with a Density Gradient," by W. E. Hart, M.S. Thesis, Univ. of California, 1961.
- (3679) ANALYSIS OF WATERSHEDS AS NONLINEAR SYSTEMS.
- (b) Water Resources Center, University of Calif., Berkeley, California.
- (c) Prof. J. Amorocho, Univ. of Calif., Davis, Calif., and Prof. G. T. Orlob, Univ. of Calif., Berkeley, California.
- (d) Theoretical and experimental investigation of the behavior of catchments as nonlinear systems.
- (e) The investigation is summarized as follows; (1) Study of the application of methods of nonlinear analysis to the determination of the impulse response functions in hydrologic systems. (2) Laboratory investigation of the behavior of small catchments with regard to the nonlinearity of their response to inflow under various conditions. (3) Development of approximate procedures for the establishment of nonlinear inflow-outflow relationships for small catchments.
- (g) Experiments completed to date on laboratory catchments under simulated rain reveal large departures from the conditions of linearity and invariance implicit in the "unit hydrograph" concept, and suggest that similar behavior can be expected in natural watersheds. A new approach in the analysis of flood episodes in small watersheds is suggested and approximate procedures applicable to floods due to uniformly distributed storms have been developed.
- (h) "Analysis of Hydrologic Units as Nonlinear Systems," J. Amorocho, Hydraulic Laboratory and Sanitary Engineering Research Lab., -- Water Resources Center Contribution--Univ. of California, Berkeley.
- (4077) NEARSHORE SEDIMENT MOVEMENT.
- (b) National Science Foundation.
- (d) Experimental (laboratory and field).
- (e) The objective of this investigation is to determine the overall sand balance for selected localities and to explain changes quantitatively. Special consideration is given to sediment conditions at the mouths of large sediment-carrying rivers, submarine canyon heads, and major headlands.
- (4078) BEACH BACKGROUND RADIOACTIVITY.
- (b) Atomic Energy Commission, Washington, D. C.
- (c) Prof. Parker D. Trask, Dept. of Mineral Technology and Hydraulic Research Lab., Univ. of Calif., Berkeley, California.
- (d) Field observations and theoretical considerations.
- (e) Purpose of project is to measure variations in background radioactivity of beaches in vicinity of San Francisco with the object of determining the normal background, its seasonal variations and variation in radioactivity from place to place at any one time.
- (g) The work has been in progress for only a few months. In addition to establishing normal background radiation, the variations in radiation from Thorium and Uranium minerals from place to place and from time to time on the different beaches give promise of yielding information on patterns of sand movement.
- (4079) WAVE FORCES ON BREAKWATERS.
- (b) Laboratory project.
- (d) Experimental; basic research; for doctor's thesis.
- (e) Experimental investigation of the wave forces that act on the individual capstones in an idealized rubble-mound breakwater. The magnitude of the wave forces and their distribution with depth was determined, as well as the kinematic conditions causing the forces.
- (f) Completed.
- (g) The most dangerous forces from the standpoint of breakwater failure occur under the toe of an advancing breaker or when water is flowing out of the breakwater.
- (h) "Wave Forces on Breakwaters," Gunnar Sigurdsson, Ph. D. Thesis, August 1961.
- (4080) FLOW THROUGH ANISOTROPIC POROUS MEDIA.
- (b) Laboratory project.
- (d) Analytical and experimental; basic research.
- (e) This study is concerned with the directional permeabilities in layered anisotropic porous media. Analytic results are being compared with measurements on an electric analog.
- (g) Directional permeabilities as functions of orientation, spacing, and size of layers have been evaluated. A report is in preparation.
- (4081) RECHARGE OF WASTES IN UNDERGROUND FORMATIONS.
- (b) Livermore Radiation Lab., Livermore, Calif.
- (d) Experimental; basic and applied research.
- (e) This study is designed to evaluate the hydraulics of fluid flow from an underground cavity fed by a recharge well into surrounding aquifers. Results are expected to assist in field studies of disposal of industrial wastes, brines, and radioactive materials.
- (4082) CAVITATION IN A VENTURI.
- (b) Laboratory project.
- (c) Prof. H. W. Iversen, Dept. of Mech. Engrg., University of Calif., Berkeley, California.
- (d) Experimental and theoretical basic research.
- (e) Macroscopic nature of cavitation formation and collapse with inter-relationships of

- head losses on collapse and with liquids of different vaporization properties.
- (g) Tests with water over a 60 degree F - 200 degree F range of temperature are essentially completed.

UNIVERSITY OF CALIFORNIA, Department of Naval Architecture.

(3026) SHIP RESISTANCE IN UNIFORM WAVES AS A FUNCTION OF BLOCK COEFFICIENT AND WAVE STEEPNESS.

- (b) David Taylor Model Basin, Dept. of the Navy.
- (c) Mr. O. J. Sibul, Room 224, Bldg. T-3, Univ. of Calif. Berkeley, California.
- (d) Experimental.
- (e) A series of experiments were performed to study the effect of width (beam) and the block coefficient of the ship on the added resistance in uniform waves. The following block coefficients were used for Series 60 5-foot models: 0.60; 0.70; 0.80 and a model of DE 1006 with a block coefficient of 0.49. All of the models were towed in waves 3.75; 5.00; 6.25 and 7.50 feet long at seven different wave steepnesses between 0.0146 and 0.0684.
- (h) "Ship Resistance and Motions in Uniform Waves as a Function of Block Coefficient," by O. J. Sibul, Univ. of Calif., IER Series 61, Issue 19, June 1961.

(3029) REPRODUCTION OF RECORDED OCEAN WAVES IN A SHIP MODEL TOWING TANK.

- (b) National Science Foundation and Univ. of California.
- (c) Mr. O. J. Sibul, Room 224, Bldg. T-3, University of California, Berkeley, Calif.
- (d) Basic and applied research; design.
- (e) The work undertaken under this program was the design and construction of a power and control system for the existing wave generator, such that a recorded ocean wave in a desired scale could be reproduced in the towing tank. The system utilizes a magnetic tape input to servomechanism which makes the wave-generator follow a prescribed time-distance curve.

(3685) SHIP SLAMMING LOADS AND HULL RESPONSES.

- (b) National Academy of Sciences - National Research Council, Committee on Ship Structural Design.
- (c) Prof. H. A. Schade, Room 224, Bldg. T-3, Univ. of California, Berkeley, Calif.
- (d) Experimental and theoretical; basic and applied research.
- (e) The project involves structural as well as hydrodynamic problems. Only the latter are described here. (1) It will be attempted to determine the virtual mass distribution along the length of a vibrating beam in water (forced vibration as well as impact loading). (2) A model of an element of ship bottom structure will be dropped on a free water surface. Strains, accelerations and pressures will be measured.

(3686) NON-LINEAR COUPLED SHIP MOTIONS.

- (b) David Taylor Model Basin, Department of the Navy.
- (c) Prof. John R. Paulling, Jr., Room 224, Bldg. T-3, Univ. of California, Berkeley, California.
- (d) Theoretical with some experimental verification.
- (e) It has been shown that at certain frequencies of heave or pitch motion of a ship, a rolling motion of large amplitude may arise. This is explained in terms of instabilities of solutions of the equations of motion which include certain non-linear

coupling terms.

- (g) The relationships between natural frequencies in pitch and roll or heave and roll which lead to unstable rolling motion have been obtained theoretically and verified experimentally. Analog computational techniques have been used in investigating the effect of damping.
- (h) "Instability of Ship Motions in Longitudinal Waves Resulting from Nonlinear Coupling," by C. S. Hsu, Univ. of Calif. IER Series 173, Issue 1, May, 1961.
"On a Restricted Class of Coupled Hill's Equations and Some Applications," by C. S. Hsu, Univ. of California, IER Series 173, Issue 2, June, 1961.
"The Analysis of the Nonlinear Static Coupling Terms in Heave, Pitch, and Roll for Several Hull Forms," by William Kinney, IER Series 173, Issue 4, October, 1961.
"On the Unstable Rolling Motions of Ships Resulting From Nonlinear Coupling with Pitch Including the Effect of Damping in Roll," by William Kinney, IER Series 173, Issue 3, October 1961.

(3687) PRESSURE DISTRIBUTIONS, ADDED-MASS, AND DAMPING COEFFICIENTS FOR CYLINDERS OSCILLATING IN A FREE SURFACE.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Professors J. V. Wehausen and J. R. Paulling, Room 224, Bldg. T-3, Univ. of Calif., Berkeley, Calif.
- (d) Theoretical and experimental basic research.
- (e) A linearized theory is developed for the pressure distributions, added-mass and damping coefficients for horizontal cylinders oscillating vertically with small amplitude while semi-immersed in the free surface of a fluid of uniform depth. Calculated values are compared with values measured in experiments.
- (g) The measured values and values based on the sample calculations show similar distinctive behavior.

(4083) DYNAMIC INTERACTION BETWEEN SHIPS.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. J. R. Paulling, Room 224, Bldg. T-3, Univ. of Calif., Berkeley, California.
- (d) Theoretical and experimental.
- (e) The linearized equations of motion for two ships operating on parallel courses are formulated. Coefficients appearing in these equations are being evaluated by captive model techniques. Analog and digital means of solving the equations are being studied.
- (g) Static yaw and rudder angles of the two ships have been calculated using data obtained in experiments by other investigators.

(4084) SHIPS OF MINIMUM RESISTANCE.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. J. V. Wehausen, Room 221, Bldg. T-3, Univ. of Calif., Berkeley, California.
- (d) Theoretical applied research.
- (e) The usual minimum problem for ship wave resistance fixed the profile and volume and minimizes Michell's Integral among some given class of functions describing the whole ship. Since the theory assumes irrotational flow of an inviscid fluid, it does not take account of the effects of viscosity, e.g., the possibility of a separated boundary layer for certain forms nor of the necessity of fitting a propeller astern. Here one tries to take account of this by fixing the afterbody as one known to be satisfactory, and then allowing only the forebody to vary among a given class of

- functions.
- (h) "Ships of Minimum Wave Resistance," by J. V. Wehausen, G. Reichert, and J. R. Gauthey. University of Calif. IER Series 82, Issue 21, October 1961.
- (4085) EFFECT UPON WAVE RESISTANCE OF THE INITIAL ACCELERATION OF SHIP MODELS.
- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. J. V. Wehausen, Room 221, Bldg. T-3, University of Calif., Berkeley, Calif.
- (d) Theoretical applied research.
- (e) An asymptotic expansion for large t is obtained for the wave resistance of a thin ship started from rest and accelerated to a final velocity c in a time t . The result indicates an oscillation about the limiting value (Michell's Integral) which is damped like $(t - t_0)^{-1}$. The period T is given by $gT/c_0 = 8\pi$. A computation is carried through for a simple ship form.
- (h) "Effect of the Initial Acceleration upon the Wave Resistance of Ship Models," by J. V. Wehausen, Univ. of Calif. IER Series 82, Issue 22, December 1961.

UNIVERSITY OF CALIFORNIA, Institute of Industrial Cooperation, Department of Engineering.

(3680) OPTIMIZATION OF WATER RESOURCES DEVELOPMENT.

- (b) Water Resources Center, Univ. of California.
- (c) Prof. Warren A. Hall, Univ. of California, Los Angeles 24, California.
- (d) Theoretical; basic.
- (e) Mathematical techniques are being developed for optimization of water resource development, including rational cost allocation using dynamic programming.
- (g) An overall model has been developed. Optimum design of aqueducts and corresponding cost allocation for planning and design purposes has been analyzed.
- (h) "Optimum Irrigation Practice Under Conditions of Short Supply," by W. A. Hall and N. Buras, Trans. of the American Society of Agricultural Engineers, Vol. 4, No. 1, 1961.
- "The Dynamic Programming Approach to Water Resources Development," by W. A. Hall and N. Buras, Journal of Geophysics Research, Vol. 66, No. 2, 1961.
- "Aqueduct Capacity Determination Under an Optimum Benefit Policy," W. A. Hall, Proc. of the American Society of Civil Engineers, Vol. 87, # IR3, Sept., 1961.
- "A Method for Allocating Costs of a Water Supply Canal," W. A. Hall, submitted for publication, Journal A.S.C.E., 1960.
- "An Analysis of Reservoir Capacity Requirements for Conjunctive Use of Surface and Ground Water Storage," N. Buras and W. A. Hall, Proc. of the International Assoc. for Hydrology, Athens, Greece, 1961.

(3681) HYDRAULICS OF SURFACE IRRIGATION.

- (b) Agricultural Experiment Station, Univ. of Calif., Davis, California.
- (c) Prof. W. A. Hall, Univ. of Calif., Los Angeles 24, Calif.
- (d) Theoretical and experimental; basic and design.
- (e) An investigation in the hydraulic characteristics of surface irrigation with particular reference to design of surface irrigation systems.
- (g) The unsuitability of Manning's equation for shallow, very rough flows has been demonstrated. The general time-distance relationships for border flows have been derived for an advancing stream (unsteady). Application of these results to system design has been made.
- (h) "Performance Parameters of Irrigation Systems," W. A. Hall, Transactions of

American Society of Agricultural Engineers, Vol. 3, No. 1, 1960.

(3683) FOUNDATIONS AND EARTH STRUCTURES IN EARTHQUAKES.

- (b) Laboratory project.
- (c) Prof. J. Morley English, Vice-Chairman - Research, Department of Engineering, Univ. of Calif., Los Angeles 24, California.
- (d) Field investigation; applied research.
- (e) Continued study of response of earth structures, foundations, and waterfront structures to earthquake. A field investigation of structures of this type was carried out after the 1960 earthquakes in Chile.
- (g) Significant damage to a variety of foundation quay walls, and earth structures was observed in Chile after the May 1960 earthquake. Bridge piers rotated, sea walls failed, and landslides were common. Poor soil foundation remarkably aggravated the damage to structures. Earthquake-induced liquefaction of loose sandy soil was dramatically present.
- (h) "Soil, Foundation, and Earth Structure Behavior in the Chilean Earthquakes of May 1960," C. M. Duke and D. J. Leeds, presented to the Seismological Society of America, Annual Meeting, San Diego, April, 1961, and requested for publication in the Bulletin of the Society.

UNIVERSITY OF SOUTHERN CALIFORNIA, Research Foundation for Cross-Connection Control.

Inquiries concerning the following projects should be addressed to Dr. K. G. Reynolds, Supervisor, Research Foundation for Cross-Connection Control, University of Southern California, Los Angeles 7, California.

(49) RESEARCH FOUNDATION FOR CROSS-CONNECTION CONTROL.

- (b) Laboratory project.
- (d) Experimental research and field investigations; basic research.
- (e) To determine by proper research the relative value and protection afforded by various backflow prevention devices.
- (g) Establishment of standardized laboratory and field test procedures and minimum specification requirements for backflow prevention equipment and continuous evaluation and improvement of such procedures and specifications.

UNIVERSITY OF SOUTHERN CALIFORNIA, Dept. of General Engineering, Fluid Mechanics Laboratory.

Inquiries concerning the following projects should be addressed to Prof. Herbert H. Spencer, Dept. of General Engineering, Fluid Mechanics Laboratory, University of Southern California, Los Angeles 7, California.

(4089) STABILITY OF HYDRAULIC JUMP.

- (b) Laboratory project.
- (d) Experimental; applied research for master's project.
- (e) Design and construction of special flume to study stability of hydraulic jump as a function of Froude Number.

(4090) WIND PRESSURE ON ROOFS.

- (b) Laboratory project.
- (d) Experimental; applied research for baccalaureate project.
- (e) Experimental study of wind pressure distribution on various contemporary shapes of roofs.

(4091) MAGNETOHYDROSTATICS.

- (b) Laboratory Project.
- (d) Theoretical and experimental; basic research.
- (e) Study of the pressure distribution in liquids under the action of electro-magnetically induced body forces.
- (f) Analysis and preliminary experiments completed.
- (h) Report available on loan.

(4092) INCOMPRESSIBLE TWO-DIMENSIONAL SOURCE FLOW.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) Study of pressure distribution and forces generated.
- (f) Completed.
- (g) The analysis of this problem by the methods of Classical Hydraulics is not confirmed.
- (h) Report available on loan.

CARNEGIE INSTITUTE OF TECHNOLOGY, Department of Civil Engineering.

Inquiries concerning the following projects except when otherwise indicated should be addressed to Dr. T. E. Stelson, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh 13, Pennsylvania.

(1834) AIR-WATER FLOW.

- (b) Laboratory project.
- (d) Analytical and experimental.
- (e) Study of air-binding in pipelines. Particular attention is given to the mechanism and relationships causing separation of air into pockets, re-entrainment of air at a turbulent interface and energy losses associated with the phenomenon.
- (g) Experimental studies of 2 and 6 in. diameter pipes have been completed for a variety of flow conditions.

(2064) VIRTUAL MASS.

- (b) Laboratory project.
- (d) Analytical and experimental.
- (e) Determination of the inertia drag on bodies moving in fluids in rotational motion and under varying conditions of translational motion.

(2275) FLOW OF LIQUID-SOLID MIXTURES.

- (b) Laboratory project.
- (d) Analytical and experimental.
- (e) Study of the movement of granular material carried in a fluid through closed conduits. Measurements of velocities, energy losses, concentrations and segregated conditions are made.

(3203) PRESSURE SURGES IN CLOSED CONDUITS.

- (b) Laboratory project - National Science Foundation Fellowship.
- (d) Analytical and experimental.
- (e) Determination of pipe geometry on the reflection and transmission of pressure surges in closed conduits.

(3235) FLOW OF LIQUID-SOLID MIXTURES IN INCLINED PIPES.

- (b) Laboratory project.
- (d) Analytical and experimental.
- (e) Study of the special problems that develop when liquid-solid mixtures are carried in inclined pipes.

(3300) MECHANICS OF NON-NEWTONIAN FLOWS.

- (b) Laboratory project.
- (c) Dr. G. Bugliarello, Dept of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13,

Pennsylvania.

- (d) Analytical and experimental.
- (e) Study of energy relationships, velocities and flow structure in non-newtonian flows.

(3689) PHASE SEPARATION EFFECTS IN THE FLOW OF BLOOD.

- (b) National Institutes of Health.
- (c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pennsylvania.
- (d) Analytical and experimental.
- (e) Study of the magnitude of the phase separation effect in the flow of blood for vessels of different sizes and configurations, both under steady and pulsating flow conditions.

(3690) FLOW CHARACTERISTICS OF FOAMS.

- (b) National Institutes of Health.
- (d) Experimental and analytical.
- (e) Study of the flow characteristics of foams in closed conduits and open channels of varying geometry.

(3691) WAVE PROPAGATION IN SOLID-LIQUID MIXTURES.

- (b) Laboratory projects.
- (c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
- (d) Experimental and analytical.
- (e) Study of the celerity and intensity of pressure waves in solid-liquid mixtures of different characteristics flowing in pipes.

(3692) SEPARATION FLOW OF SOLID-LIQUID MIXTURES.

- (b) Allegheny County Sanitary Authority.
- (d) Experimental and analytical.
- (e) In the separation or divergence of flowing liquid-solid mixtures unbalanced concentrations frequently occur in the different channels. Methods are being developed to predict and control the unbalance.

(4093) VIBRATORY MOTIONS OF FLOATING BODIES.

- (b) Office of Naval Research, Dept. of the Navy.
- (d) Experimental and analytical.
- (e) Development of theory for determining wave pattern and virtual mass and damping in the three-dimensional flow field around a shallow ship.

(4094) MOLECULAR DIFFUSION STUDIES BY RANDOM WALK METHODS.

- (b) Laboratory project.
- (c) Dr. G. Bugliarello, Civil Engineering Dept., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
- (d) Analytical.
- (e) Development of computer programs for the study of molecular diffusion in a laminar shear flow using random walk methods.

(4095) HIGH PRESSURE LIQUID FLOWS.

- (b) Laboratory project.
- (c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
- (d) Experimental.
- (e) Study of laminar and turbulent flow of various liquids between concentric cylinders, under pressures up to 15,000 psi.

(4096) FLOW OF SOLID-LIQUID MIXTURES AT BIFURCATIONS.

- (b) Laboratory project.
- (c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
- (d) Experimental.
- (e) Study of the effect of bifurcations on the concentration of solid-liquid mixture in the laminar and turbulent flow range in closed conduits.

(55) SNOW SURVEY.

- (b) Colorado Agricultural Experiment Station, Soil Conservation Service, several Rocky Mountain States.
- (c) Mr. Jack N. Washichek, Snow-Survey leader, Agric. Engineering Section, Colo. State Univ., Fort Collins, Colo.
- (d) Applied.
- (e) Snow course measurements are taken and forecasts of annual runoff are made for all the drainage basins of the state.
- (g) Forecasts are made approximately April 1 for the forthcoming spring and summer.

(821) GROUND WATER FLUCTUATIONS AND THEIR RELATION TO PUMPING.

- (b) Colorado Agricultural Experiment Station.
- (c) Mr. M. M. Skinner, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colo.
- (d) Field investigation; applied research.
- (e) An extensive observation well network is being established capable of providing reliable information on the fluctuation of the ground-water table in each of the several ground-water basins in Colorado. Periodic measurements of ground-water table elevations are being made at each of the selected observation wells. Procedures are being developed for processing, cataloging, analyzing the resultant data by machine methods.
- (g) Due to an unusually large amount of rain-fall during the summer months (1961) in eastern Colorado, the water tables in that area are generally up 2 to 3 feet over the 1960 fall measurements.

(2514) ALLUVIAL CHANNEL HYDRAULICS

- (b) U. S. Geological Survey.
- (c) Dr. D. B. Simons, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colo.
- (d) Theoretical, experimental and laboratory research, basic research.
- (e) This is a study of the mechanics of flow in alluvial channels.
- (g) Five different bed materials ranging in size from 0.19 mm to 0.93 mm have been studied. The forms of bed roughness ranging from ripples to antidunes have been described and related to sediment discharge and resistance to flow. The effects of large concentrations of fine sediment (clay) and temperature on sediment discharge and form of bed roughness has also been investigated. "Flume Studies Using Median Sand (0.95 mm)," by D. B. Simons and E. V. Richardson, U. S. Geological Survey Water Supply Paper 1498A, 1961.
- (h) "Sonic Depth Sounder for Laboratory and Field Use," by E. V. Richardson, D. B. Simons and G. J. Posakony, U. S. Geological Survey Circular No. 450, 1961.
- "The Variable Depth-Discharge Relation in Alluvial Channels," by D. B. Simons, E. V. Richardson and W. L. Haushild, U. S. Geological Survey Professional Paper 424D, 1961.
- "The Significance of Fall Velocity and Fall Diameter of Bed Material," by W. L. Haushild, D. B. Simons and E. V. Richardson, U. S. Geological Survey Professional Paper 424D, 1961.
- "Qualitative Effects of Temperature on Flow in Alluvial Channels," by D. W. Hubbell and K. Al-Shaikh Ali, U. S. Geological Survey Professional Paper 424D, 1961.
- "Forms of Bed Roughness in Alluvial Channels," by D. B. Simons and E. V. Richardson, Hydraulics Division Journal, ASCE, May 1961.
- "Sediment Transport in Alluvial Channels," by A. A. Bishop, Ph. D. Dissertation, Colo. State Univ., July 1961.

- (b) Colorado Agricultural Experiment Station and U. S. Weather Bureau.
- (c) Mr. Lewis O. Grant, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colo.
- (d) Field investigation; basic research.
- (e) Meteorological observations are being obtained to establish long-time records of climatological elements and to support current experiment station research which is weather dependent. The elements observed are: Maximum and minimum temperature and wet and dry bulb temperatures every two hours; soil temperatures at 3, 6, 12, 24, 36, and 72 inches; wind direction and velocity at 15 inches and 65 feet above ground; barometric pressure; evaporation from a free water surface; surface water temperature; precipitation; cloud cover; dew and frost.
- (g) Complete meteorological observations have been made throughout the year. Since April 1961 complete observations have been made at two sites in connection with a change in location of approximately 400 feet to the NNW. Record monthly precipitation was observed in March, and the accumulative precipitation through 15 November of 27.90 inches exceeds the 70 year record annual precipitation of 27.57 inches at Fort Collins.

(2770) SHEAR STRESS AT A LIQUID-SOLID INTERFACE BY ELECTROKINETIC POTENTIAL.

- (b) National Science Foundation.
- (c) Dr. J. E. Cermak, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Experimental research; basic research, doctoral thesis.
- (e) The primary objective is the determination of temporal fluctuations in shear stress at the fluid-solid interface in a pipe and jet flow. Fluctuation frequencies and relative amplitudes at different points along the pipe have been measured for a range of Reynolds numbers. The effect upon shear stress fluctuations of (1) pipe entrance disturbances, (2) disturbances in turbulent flow, (3) a periodic growth and decay of the laminar sublayer (as postulated by Einstein) will be investigated.
- (h) "Electrokinetic-Potential Fluctuations Produced by Turbulence at a Solid-Liquid Interface," by Gilbert J. Binder, Ph.D. Thesis, 1961.

(2902) DEVELOPMENT IMPROVEMENT OF WATER MEASURING DEVICES.

Cooperative project with Colorado Agricultural Experiment Station and Agricultural Research Service. See U. S. Department of Agriculture, Agricultural Research Service, page 92.

(3034) DISTRIBUTION AND CONCENTRATION OF RADIOACTIVE WASTE IN STREAMS BY FLUVIAL SEDIMENT.

- (b) U. S. Geological Survey, for Reactor Development Branch of the Atomic Energy Commission.
- (c) Mr. D. W. Hubbell, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, experimental and laboratory research, field investigation; basic research, applied research.
- (e) Natural streams provide a convenient and effective medium for the disposal of low-level radioactive wastes. When radionuclides are introduced in streams they may become fixed on sediment particles. As a result, waste disposal depends, in part, on the transport and dispersion of the sediment. Project activity includes field and laboratory studies on the application and development of transport and dispersion theory for bed and suspended load. In addition, some phases of the dispersion of liquid contaminants are being studied.

- (g) An experiment in which polyethylene particles were released from a point source at the water surface of an 8 foot wide alluvial channel having small dunes was performed to provide data on lateral diffusion. One field experiment and two laboratory flume experiments have been conducted on the dispersion of contaminated bed load particles. In the experiments sand labelled with radioactive isotopes has been released on the channel bottom, then traced with underwater radiation-detection equipment.
- (h) "Uptake and Transport of Radionuclides by Stream Sediments," by W. W. Sayre, H. P. Guy and A. R. Chamberlain, in preparation as a U. S. Geological Survey Professional Paper.
- (3035) THE CONSEQUENCES OF MODEL RESTRAINT ON RESULTS OF SEAWORTHINESS TESTS.
- (b) David Taylor Model Basin, Navy Department, Washington 7, D. C.
- (c) Mr. E. F. Schulz, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Experimental measurements are being made of forces and moments acting on a completely restrained model being towed on different headings in a regular wave train.
- (f) Completed.
- (g) A five-foot model tanker was equipped with a six component force balance and fitted to a towing carriage. The model was towed at different speeds on different headings in a regular wave train. The variation of the oscillatory forces and moments resulting from the waves acting on the model were obtained.
- (h) "Restrained Model Tests in Head Seas," by E. F. Schulz, prepared for David Taylor Model Basin, CER59EFS7, March 1959.
"Forces and Moments on a Restrained Model in Regular Waves," by E. F. Schulz, in preparation for David Taylor Model Basin, December 1961.
- (3037) ATMOSPHERIC SURFACE LAYER PHENOMENON.
- (b) National Science Foundation, Washington 25, D. C.
- (c) Dr. J. E. Cermak, Civil Engineering Section, Colo. State Univ., Fort Collins, Colo.
- (d) Experimental research; basic research, doctoral thesis.
- (e) Measurements of mean velocities and mean temperatures together with turbulence intensities and correlations have been made over a smooth, plane, heated or unheated surface.
- (g) Heating of the turbulent boundary layer at low Reynolds numbers has been found to produce the following effects: (1) increase the coefficient of drag; (2) increase the eddy viscosity; (3) increase the correlation between vertical and horizontal velocity fluctuations.
- (h) "Separation Flow Downstream of a Plate Set Normal to a Plane Boundary," by H. S. Nagabhushanaiah, Ph. D. Thesis, Dept. of Civil Engineering, Colo. State Univ., 1961.
- (3395) FUNDAMENTAL STUDY OF A SUBMERGED AND NONSUBMERGED THREE-DIMENSIONAL JET IMPINGING UPON A NORMAL PLANE.
- (b) National Science Foundation.
- (c) Mr. George L. Smith, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, experimental; basic research, doctoral thesis.
- (e) This is an analytical and experimental study of an axisymmetrical flow impinging normally on a smooth and rough flat boundary. The impinging jet can be divided into four zones: zone of establishment, zone of established flow in the vertical direction, deflection zone and zone of radial flow. Measurements of velocity profiles and turbulent intensities have been completed in the zone of radial flow for the case of the smooth boundary. A device for direct wall shear stress measurement has been designed, constructed and tested. The shear meter with static sensitivity of 10⁻⁶ lb. per sq. in. provides acceptable consistent data; however, its dynamic accuracy is poor because of the effect of vibration.
- (g) The turbulent intensities in the radial, vertical and circumferential directions have been measured. The local energy expressed by q^2/u^2 is a minimum at the point of maximum velocity U_m . The measured turbulent shear U_y has been measured, and its extrapolation to the boundary is found to approximate the friction coefficient obtained by shear meter. The friction coefficient in the divergent flow was found to be much larger than the coefficient for the case of the two-dimensional jet.
- (3398) WIND TUNNEL MODELING OF ATMOSPHERIC DIFFUSION.
- (b) National Institute of Health, Public Health Service, U. S. Dept. of Health, Education and Welfare, Washington, D. C.
- (c) Dr. J. E. Cermak, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Experimental research; basic research, doctoral thesis.
- (e) The objective of this project is to determine the influence of geometrical factors (land surface roughness, topography, structures), and thermal and aerodynamical factors (turbulence intensity and scale) upon atmospheric diffusion of heat and mass. "Laws of modeling" or "similitude parameters" are sought by obtaining detailed data under various conditions in the wind tunnel and by comparing them with similar data now existing for the atmospheric prototype.
- (h) "Diffusion from a Point Source Within a Turbulent Boundary Layer," by Mr. Kersi Davar, Ph. D. Thesis, 1961.
- (3399) ANALYSIS OF PRECIPITATION DATA IN THE UPPER COLORADO RIVER BASIN.
- (b) State of Colorado.
- (c) Dr. Richard A. Schleusener, Civil Engrg. Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical; basic and applied research.
- (f) Completed.
- (g) A sample of daily precipitation and temperature data from 30 weather observing locations in and near the Upper Colorado River Basin have analyzed by computer techniques. Frequency of precipitation at multiple time intervals for each location are presented. Major storms with an average recurrence interval of less than once per year have been found to contribute significantly to runoff from the Upper Colorado River Basin. Moisture sources for the basin are primarily from the Gulf of Mexico in summer, and from the Pacific Ocean during other seasons.
- (h) "Analysis of Precipitation Data in the Upper Colorado River Basin," by Richard A. Schleusener and Loren W. Crow, Civil Engrg. Report CER61RAS52, October 1961.
- (3400) HYDRAULICS OF SUB-CRITICAL FLOW IN SMALL, ROUGH CHANNELS.
- (b) Colorado Agricultural Experiment Station and Agricultural Research Service, U. S. Department of Agriculture.
- (c) Mr. Norman A. Evans, Agricultural Engrg. Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, laboratory experiment.
- (e) Tilting flume with rough channels formed in natural soil and stabilized with chemical spray. Channel shape and roughness is varied.
- (g) Method of characterizing surface roughness was developed. An empirical analysis of

- flow in the laminar range produced a formula for predicting flow resistance, criteria for determining the transition between laminar and turbulent flow, and criteria for the boundary roughness necessary to affect laminar flow.
- (h) "The Influence of a Rough Boundary on Laminar Flow," by C. W. Huntley, M.S. thesis, Colorado State University, 1961.
"Hydraulics of Subcritical Flow in Small, Rough Channels," by E. G. Kruse, USDA-ARS 41-43, October 1960.
- (3401) DRAINAGE OF IRRIGATED LANDS.
- (b) Colorado Agricultural Experiment Station and Agricultural Research Service, U. S. Dept. of Agriculture.
- (c) Mr. Norman A. Evans, Agricultural Engrg. Sec., Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical and applied.
- (e) An empirical equation for predicting water yield from tile drain systems in Northeastern Colorado was developed by correlation analysis on field data. Theoretical and laboratory studies of drainage properties of soils have developed a promising method for relating the significant flow properties (permeability, capillary pressure, saturation) for flow above the water table.
- (g) Gas permeability as a function of capillary pressure and saturation can be used to predict liquid permeability as a function of capillary pressure or of saturation.
- (h) "Hydraulic Characteristics of Porous Media," by R. H. Brooks and A. T. Corey, AE39ATC16, November 1961.
- (3693) CONSOLIDATION OF SOILS.
- (b) National Science Foundation.
- (c) Dr. I. S. Dunn, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, experimental and laboratory research; basic research, doctoral thesis.
- (e) The study consists of a mathematical analysis of the effect of viscoplastic resistance on the rate of pore pressure decrease and of an experimental program to verify the mathematical results and to investigate the effect of varied load increments on the time-consolidation relationship. The mathematical analysis will be carried out by adding viscoplastic resistance terms to the basic differential equation of consolidation developed by Terzaghi and solving the resulting equation either by standard methods or by analysis of a theoretical model. The solution of this system along with the laboratory consolidation curves will be used to produce the relationships between plastic resistance and related variables such as speed of deformation and percent of deformation.
- (f) Completed.
- (3695) CHARACTERISTICS AND FORMATION OF HAIL.
- (b) National Science Foundation.
- (c) Dr. Richard A. Schleusener, Assoc. Research Engineer, Colo. State Univ., Fort Collins, Colorado.
- (e) Basic information on hailfalls and precipitation is being obtained from a special network of cooperative observers and specialized instrumentation. Data on hail intensity, amounts, and structure of individual stones are being obtained to relate to the environment in which the storms form to obtain a better understanding of the hail formation process.
- (g) (1) Hail is favored in a broad-scale synoptic environment in which a 500 millibar "relative velocity maxima" moves through the latitude of hail occurrence. (2) Movement of precipitation cells which contain hail tends to be clockwise from the 500 millibar wind direction with a speed approximately that of the 500 millibar wind. (3) Information is available on frequency, duration, density and diurnal variation of hail. (4) The total quantity of ice that falls as hail, as well as the estimated impact energy per unit area from hail, appears to be closely related to crop damage.
- (h) "Hail Genesis Areas in and Near Northeastern Colorado," by Richard A. Schleusener and Thomas J. Henderson, Atmospheric Science Tech. Paper 21, Colorado State University, October 1961.
- (3696) STUDY OF CLOUDS AND SNOWFALL IN THE ROCKY MOUNTAINS, AND CHANGES RESULTING FROM THE ADDITION OF ARTIFICIAL ICE NUCLEI.
- (b) National Science Foundation, Rocky Mountain Forest and Range Experiment Station, and the Climax Molybdenum Company.
- (c) Mr. Lewis O. Grant Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
- (d) Field investigation; basic research, applied research.
- (e) Various physical factors important in "Cold Cloud" orographic precipitation processes are being investigated under winter-time conditions in the high mountains of Colorado. This includes observations of airflow over the mountains, the characteristics of the "cold" orographic clouds rising over the mountains, the availability of suitable ice nuclei, the characteristics of individual snow particles falling from these clouds, snow water freezing characteristics, snowfall amounts, and the changes in these conditions when artificial ice nuclei are supplied.
- (g) Field equipment and procedures for use at high elevations in the Colorado Rockies have been developed. Observations of the daily accumulation of snowfall, atmospheric ice nuclei, and various other cloud and snow characteristics have been made over a large area for seeded and unseeded days during two winter seasons. Significant increases in ice nuclei have occurred in the area of the observation network, on a number of the "seeded" days. Snowfall has been greater on the seeded days. The sample size is to be increased before determination of the statistical significance of this apparent increase in snowfall.
- (h) "Snowfall and Snowfall Accumulation near Climax, Colorado," by Lewis O. Grant and Richard A. Schleusener, to be published in the Proceedings of the April 1960 Western Snow Conference.
"Progress Report on Cloud Seeding in Central Colorado," by Lewis O. Grant, to be published in the Proceedings of the 16th Annual Meeting of the Colorado River Forecast Committee.
- (3697) MEASUREMENT OF ATMOSPHERIC OZONE WITH THE DOBSON SPECTROPHOTOMETER.
- (b) Air Force Cambridge Research Center, L. G. Hanscom Field, Bedford, Massachusetts.
- (c) Mr. Lewis O. Grant, Civil Engineering Section, Colo. State Univ., Fort Collins, Colo.
- (d) Basic research.
- (e) Measurements of the total amount and the vertical distribution of ozone with height are being made with the Dobson Spectrophotometer. Daily amounts of total ozone are being related to atmospheric circulation patterns.
- (g) Observations of total ozone and the vertical distribution with height have been made on a regular basis for days when sky conditions have been clear.
- (h) Observational data is being supplied to the U. S. Weather Bureau for publication.
- (3700) UNSTEADY FLOW IN STORM DRAINS, GENERAL AND ANALYTICAL STUDY.
- (b) U. S. Bureau of Public Roads.
- (c) Dr. V. M. Yevjevich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.

- (d) Theoretical; basic research.
- (e) The project consisted of an analytical study of unsteady free surface flow in a storm drain, considering the study as the initial step for a basic research program in developing new methods for storm flood routing in drains, using a digital computer.
- (f) Completed.
- (g) The basic partial differential equations, and especially their initial and boundary conditions, for unsteady free surface flow are discussed and analyzed as the basis for the experimental hydraulic and numerical digital computer investigations.
- (h) "Unsteady Free Surface Flow in a Storm Drain, General and Analytical Study," by Vujica M. Yevdjovich, Colorado State Univ. Engineering Research Report CER61VMY38, June 1961.
- (3701) CURB OPENINGS.
- (b) U. S. Bureau of Public Roads.
- (c) Mr. S. S. Karaki, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colo.
- (d) Experimental; applied research.
- (e) Laboratory data on prototype-size highway sections were taken to determine the efficiency of curb opening drains on highway pavements. The Bureau of Public Roads is using the data to compile design curves for highway engineers.
- (f) Completed.
- (h) "Depressed Curb Opening Inlets - Supercritical Flow - Experimental Data," by S. S. Karaki, prepared for U. S. Department of Commerce, Bureau of Public Roads, June 1961.
- (3703) MODEL-PROTOTYPE RELATIONSHIPS FOR FLOW AND SEDIMENT TRANSPORT IN ALLUVIAL CHANNELS.
- (b) National Science Foundation.
- (c) Dr. D. B. Simons, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, experimental and laboratory research; applied research.
- (e) Flume studies have been made to investigate variation in stage-discharge and sediment transport and deposition in the vicinity of several types of control structures using different sediments. Attempts have been made to correlate model prototype relations with regard to sediment size.
- (f) Completed.
- (g) The results illustrate the effect of size of bed material and form of bed roughness on control structures for alluvial streams. A non-silting structure with a fairly stable stage-discharge relation for a large range of sediment and water discharge has been developed. This work was done by Dr. J. D. Lawson, University of Melbourne, Australia.
- (h) "Flow Characteristics of Low Weir Structures in Alluvial Streams," by J. D. Lawson, Colo. State University Engineering Research Report in preparation.
- (3704) SEALING OF CANALS AND RESERVOIRS WITH COLORADO CLAYS.
- (b) State of Colorado.
- (c) R. D. Dirmeyer, Jr., Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
- (d) Laboratory research, field investigation; applied research, development.
- (e) The purposes of this project are: (1) To inventory the clay deposits in or close to major irrigated areas in Colorado. This inventory is to include both field and laboratory evaluations of the clays. (2) To develop methods of utilizing the locally-available clays in sealing leaky canals and reservoirs in Colorado.
- (g) Results to November 1961 include: (1) Laboratory testing of over 200 clay samples from 99 deposits in Colorado has been completed; (2) field evaluations of approximately 96 installations of Colorado clay in canals and reservoirs have been completed.
- (h) "Sealing Rocky Ditches with Clay," by R. D. Dirmeyer, Jr., M. M. Skinner, and R. T. Shen, Colorado State University Circular, 16 pp., December 1961.
- (3705) ANALYTICAL STUDY OF LOCAL SCOUR.
- (b) The U. S. Bureau of Public Roads.
- (c) Dr. V. M. Yevdjovich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, experimental laboratory research; basic research, doctoral thesis.
- (e) A study has been made of the scour around bridge piers and abutments using theoretical or laboratory experiments.
- (f) Completed.
- (g) By using dimensional analysis the maximum scour depth around the abutments is found to be an exponential of time, and the constants of the function are determined from experimental laboratory data in relation to dimensionless parameters in a more accurate way than it was done in previous works. The theoretical approach to the mechanics of scour around bridge piers and abutments is analyzed.
- (3707) WHITE SANDS WIND TUNNEL.
- (b) White Sands Missile Range, White Sands, New Mexico.
- (c) Mr. E. J. Plate, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Laboratory research; design.
- (e) A low-speed wind tunnel was designed for use in calibrating and standardizing wind measuring instruments. The test section will be 4 x 4 x 4 feet in size and will have an air speed range from 1/2 to 70 mph. The variation in air speed for a given setting will not vary by more than plus or minus one percent in space or time excepting within the boundary layers formed on the walls. Turbulence levels will not exceed 0.2 percent at any air speed.
- (f) Completed.
- (g) The wind tunnel has been designed, constructed, and installed.
- (3708) INVESTIGATIONS TO DEVELOP WIND TUNNEL TECHNIQUES FOR MEASURING ATMOSPHERIC GASEOUS DIFFUSION IN MODEL VEGETATIVE SURFACES.
- (b) Agricultural Research Service, U. S. Dept. of Agriculture.
- (c) Mr. E. J. Plate, Civil Engineering Section, Colorado State Univ., Fort Collins, Colorado.
- (d) Laboratory research; basic research, applied research for thesis (doctoral).
- (e) Diffusion of a gas (ammonia) into and out of a model vegetated plane area contributing part of a wind tunnel test section floor is to be studied. Using a test section 80 ft long and 6 x 6 ft in cross-section the turbulent boundary layer in which diffusion occurs will be several times thicker than the vegetation height. Using the basic equations of fluid mechanics, an attempt will be made to establish criterion for application of the model data to prototype conditions. The criterion developed will be checked using field data being obtained at Cornell University by the Agricultural Research Service.
- (g) A study of diffusion from a line source into a boundary layer over a flat, smooth plate has been completed. Results show that the diffusion pattern can be separated into different zones, according to distances from the source in which different similarity laws are valid for the diffusion process.
- (h) "Diffusion from a Line Source in a Turbulent Boundary Layer," by Michael Poreh, Ph.D. Dissertation, October 1961.
- (3709) CONSTRUCTION OF MICROMETEOROLOGICAL WIND TUNNEL.
- (b) U. S. Signal Corps.

- (c) Mr. E. J. Plate, Civil Engineering Section, Colorado State University, Fort Collins, Colorado.
 - (d) Laboratory research; design
 - (e) A wind tunnel is being designed and constructed which will permit control of air speed (1 - 150 mph), air temperature (32 - 200 degrees F) and relative humidity (5 - 95 percent). The 6 x 6 foot square by 80 foot long test section will have provisions for heating and/or cooling about 30 feet of the floor. The facility is being designed to permit detailed study of turbulence and turbulent diffusion under various thermal conditions.
 - (g) Design is completed. Construction is well on its way.
- (3710) HYDROLOGIC ASPECTS OF THE UPPER COLORADO RIVER BASIN.
- (b) Upper Colorado River States.
 - (c) Dr. V. M. Yevdjovich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Theoretical; applied research.
 - (e) By using the distributions of the first serial correlation coefficient of several stations, and distribution of ranges, the patterns in the sequence of annual river flows of the Upper Colorado River Basins are studied.
 - (f) Completed.
 - (g) The sequence of annual effective precipitations on the Upper Colorado River Basin is very close to random. A depletion model by man-made changes is derived. The sequence of annual river flows is close to random, except that the non-homogeneity in data and the water carryover from one water year to another create a dependence of successive values of river flows.
 - (h) "Some General Aspects of Fluctuations of Annual Runoff in the Upper Colorado River Basin," by Vujica M. Yevdjovich, Colorado State University Engineering Research Report CER61VMY54, October 1961.
- (4097) SILT EJECTOR MODEL FOR LINK CANALS.
- (b) Tipton and Kalmbach, Denver, Colorado.
 - (c) Mr. S. S. Karaki, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
 - (d) Laboratory research; applied research.
 - (e) A network of large canals is being constructed in West Pakistan to divert waters of the Indus River and its tributaries to cultivated lands for irrigation. In order to maintain canals in regime it is necessary to remove sediment from the canals. The width of the canals ranges from 200 to 300 feet. Normal sediment ejectors are considered unsatisfactory for the new canals, hence new devices for sediment ejection are being investigated.
 - (g) No conclusive results available to date, however, it appears that a curve in the canal to create secondary flow around the bend and utilizing the distribution of boundary shear on the bed may be an effective and economical means of transporting sediment to the inside of the curve. There the sediment which forms a shoal can be removed hydraulically.
 - (h) "Model study of the Sediment Ejector for the Trimmu-Sidhnai Link Canal," by S. S. Karaki, Interim Report, prepared for Tipton and Kalmbach, Inc., Denver, Colorado, November 1961.
- (4098) HIGH LEVEL TURBULENCE.
- (b) U. S. Navy Weather Research Facility, Bldg. R-48, Naval Air Station, Norfolk, Va.
 - (c) Dr. Elmar Reiter, Civil Engineering Section, Colo. State Univ., Fort Collins, Colo.
 - (d) Field investigation; basic research.
 - (e) By means of stereo-photography of high-level clouds a study will be made of wavelengths of disturbances in the jet-stream region, which might account for clear-air turbulence.
- (g) Cameras have been calibrated and reduction procedures programmed for electronic computer.
 - (h) "Die Feinstruktur der Strahlstroeme," by E. R. Reiter, Civil Engineering Department, Colo. State Univ., Atmospheric Sciences Tech. Paper No. 22, CER61ERR61.
- (4099) WAKE CHARACTERISTICS FOR BODIES OF REVOLUTION.
- (b) Dept. of Navy, David Taylor Model Basin, Washington 7, D. C.
 - (c) Dr. J. E. Cermak, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
 - (d) Experimental research; basic research, doctoral thesis.
 - (e) A study will be made of the relations between axially symmetrical bodies and the wakes produced by them for varying mean velocities and turbulence levels of the mean flow, both with and without momentum addition by means of a jet directed downstream from the body. Basic data will be obtained for establishing similarity criteria for turbulent and mean flow characteristics at large distances downstream from the body.
- (4100) PATTERNS IN SEQUENCE OF ANNUAL RIVER FLOWS.
- (b) National Science Foundation.
 - (c) Dr. V. M. Yevdjovich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Theoretical; basic research.
 - (e) The series of annual river runoff and the series of annual effective precipitations are analyzed by using the probability distribution of ranges and runs. The effect of the selection of beginning of a water year and of inconsistency and non-homogeneity in annual flow data on statistical parameters of above series also will be studied.
 - (g) This research project was in its initial stage in October 1961. It is a continuation of the research, carried out on the same subject and sponsored by the U. S. National Bureau of Standards (1958 - 1959), and the U. S. Geological Survey (1959 - 1960).
- (4101) UNSTEADY FLOW IN A LONG STORM DRAIN.
- (b) U. S. Bureau of Public Roads.
 - (c) Dr. V. M. Yevdjovich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Theoretical, experimental and laboratory research; basic and applied research.
 - (e) A long model conduit is being designed for hydraulic experiments of unsteady free surface flow in a storm drain. The model studies furnish the hydraulic boundary conditions for flood wave studies on a digital computer. The second group of experiments is simulation of storm flood waves through the conduit. The flood routing of the same waves by numerical integration of differential equations on a digital computer will enable comparison of numerical and hydraulic experimental flood routing. The purpose of the project is the development of methods for computing flood movement through storm drains by the use of a digital computer.
- (4102) WIND FORECASTING TECHNIQUES.
- (b) Federal Aviation Agency, Federal Aviation Facilities Center, Atlantic City, New Jersey, Attn: RD-140.
 - (c) Dr. Elmar Reiter, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Theoretical, experimental; basic and applied research.
 - (e) Automatic forecasting techniques for high-level winds which can be used by an automatic air traffic control system shall be devised and tested.

- (4103) ACCURACY OF SURVEYING INSTRUMENTS.
- (b) Wild Heerburgg Investment Company, Main and Covert Streets, Fort Washington, N. Y.
 - (c) Mr. Milton E. Bender, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colo.
 - (d) Experimental and laboratory research; applied research.
 - (e) The purpose of this study was to determine the accuracy of theodolites. Particular attention was paid to systematic errors. The data have been collected but not yet analyzed.
- (4104) SILT EXCLUDER FOR THE GUALANDAY HEADWORKS.
- (b) Tipton and Kalmbach, Inc., Denver, Colorado.
 - (c) Mr. S. S. Karaki, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Laboratory research; applied research.
 - (e) A model study was made of a silt excluder at the headworks of the Gualanday Canal on the Coello River. The Coello River is located in Columbia, South America. The Gualanday Canal has experienced considerable sediment problems and maintenance of the Canal has proved to be difficult and expensive. A different type of sediment excluder at the headworks was studied.
 - (f) Completed.
 - (g) The sediment excluder developed for the Gualanday headworks consisted of two tunnel sluices with a skimming weir to divert clear water flow into the Canal. Although developed for a particular installation, it could have application to other sites.
 - (h) "Desilting Structure at the Gualanday Canal Headworks Coello Project, Columbia, South America," by S. S. Karaki, prepared for Tipton and Kalmbach, Inc., April 1961.
- (4105) GENESIS AREAS FOR HAILSTORMS IN THE HIGH PLAINS.
- (b) Crop-Hail Insurance Actuarial Association, Chicago, Illinois.
 - (c) Dr. Richard A. Schleusener, Assoc. Research Engineer, Civil Engineering Section, Colo. State University, Fort Collins, Colorado.
 - (d) Field investigation; applied research.
 - (e) The position and movement of precipitation cells has been tracked by a 3.2 cm radar set located at New Raymer, Colorado, from 15 May to 15 August 1961. The cells that produced hail were identified from concurrent data from a special surface network. The location of genesis of these precipitation cells was related to terrain features and low-level wind flow.
 - (g) It appears that regions of hail genesis can be identified from a "lift factor" computed from terrain differences and low-level wind flow. The "lift factor" gives a measure of the distance that a parcel of air would be lifted over terrain by the 8,000 foot wind.
 - (h) "Hail Genesis Areas in and near Northeastern Colorado," by Richard A. Schleusener and Thomas J. Henderson, Atmospheric Science Technical Paper 21, Colorado State University, October 1961.
- (4106) GROUNDWATER MANAGEMENT.
- (b) Colorado Experiment Station and Colorado Department of Natural Resources.
 - (c) Mr. M. W. Bittinger, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colo.
 - (d) Theoretical, field investigation; applied research.
 - (e) The project consists of field studies to determine ground water reservoir characteristics. Management programs will later be applied to determine optimum operation techniques.
- (4107) ESTIMATING FLOOD FLOWS.
- (b) U. S. Agricultural Research Service and the State of Colorado.
- (c) Dr. V. M. Yevdjovich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Basic research; doctoral.
 - (e) Pearson type III curves are being fitted to flood hydrographs of small watersheds using three parameters: flood peak Q , flood volume V , and time lag t_0 from the flood beginning to flood peak. The parameters Q , V , and t_0 are related to several variables of small watersheds, including precipitation characteristics and probability of specific rainfall intensities. Multiple regression analysis is used to determine the significant variables.
- (4108) WATERSHED HYDROLOGY.
- (b) Colorado Agricultural Experiment Station.
 - (c) Mr. E. F. Schulz, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Experimental, field investigation; applied research.
 - (e) The small watershed provides an opportunity to study the rainfall-runoff cycle in the absence of some of the complexities involved in studying larger watersheds. Some generalizations of the hydrologic characteristics of small watersheds are being developed and the region in Colorado where these generalizations are valid will be defined.
 - (g) Project was initiated in 1961.
- (4109) METEOROLOGICAL CONDITIONS AFFECTING DENVER AIR POLLUTION.
- (b) Yetter Foundation, administered by Denver-U. S. National Bank.
 - (c) Professor of Atmospheric Science, Dr. Herbert Riehl, Colo. State Univ., Fort Collins, Colo.
 - (d) Field, applied, basic.
 - (e) Denver pollution has been steadily growing but has not yet attained extreme proportions. It will be a novel feature of this investigation that the causes and history of pollution periods will be measured and analyzed with view toward providing the basis for a sound city ordinance, before the situation has become very severe. With instrumentation furnished by the Taft Center of Sanitary Engineering, National Institute of Health, five stations recording detailed wind and temperature fluctuations have been set up in the Denver area. With collaboration of the U. S. Weather Bureau, the U. S. Air Force, and private industry six additional stations take records, so that a total of 11 stations is operating during pollution periods. The air sampling is carried out in conjunction with the project by the City of Denver; equipment also has been furnished by the Taft Center.
 - (g) The first day of observations was on 15 December 1961.
- (4110) TURBULENT AIR MOTION IN THE HIGH ROCKIES IN RELATION TO THE WATER YIELD OF UPPER WATER SHEDS.
- (b) Colorado Agricultural Experiment Station.
 - (c) Dr. Herbert Riehl, Professor of Atmospheric Science, Colo. State Univ., Fort Collins, Colorado.
 - (d) Field, basic and applied.
 - (e) The structure of the turbulent wind eddies, which produce the exchange of momentum between atmosphere and ground in the high mountains, is completely unknown. Yet these eddies have sufficient force for the most part to blow the snow away from the mountain slopes above timberline. This snow in part drifts into high-altitude basins where it accumulates in depth augmenting the summer water supply; in part it drifts on slopes where it readily evaporates. Much interest has been shown in the possibility of channeling the drift so that a substantially higher fraction goes into the basins. Technologically this appears to be feasible. But any construction is dependent on

- knowledge of the turbulence spectrum, especially on the first day following snowfall. In order to determine this spectrum, a first installation containing electronic wind and temperature measuring instruments is being installed on Cuandary Peak (14,250 feet) in the central Colorado Rockies. It will be maintained there during the 1961-62 winter. Other sites will be chosen in subsequent years. The measurements will yield detailed information on the structure of turbulence, when very fast air currents interact with major topographic features.
- (4111) THE ROLE OF THE ROCKY MOUNTAINS IN THE GENERAL CIRCULATION OF THE ATMOSPHERE.
- (b) U. S. Navy Numerical Weather Prediction Facility, Monterey, California.
 - (c) Dr. Herbert Riehl, Professor of Atmospheric Science, Colo. State Univ., Fort Collins, Colorado.
 - (d) Basic.
 - (e) The Rocky Mountains are a solitary obstacle in the path of the westerly winds which cannot be circumvented like the Himalayas. A large fraction of the exchange of angular momentum between air and ground -- estimated as high as 50 percent -- takes place in the small mountain region. The processes are direct surface stress from interaction between the high-velocity currents of the upper air and the high mountains, and a torque produced due to the pressure differential between eastern and western mountain slopes. The purpose of the project is (a) to determine the actual atmosphere-ground momentum exchange and its variation in time; (b) to determine the effect of this exchange on weather in and to the lee of the mountains; (c) to determine the importance of the momentum exchange on large-scale weather conditions around the hemisphere; and (d) to find an improved model of the surface stress term for numerical prediction purposes.
- (4112) THE DISCHARGE OF MAJOR WESTERN RIVERS IN RELATION TO THE GENERAL CIRCULATION OF THE ATMOSPHERE.
- (b) Office of Naval Research, Dept. of the Navy.
 - (c) Dr. Herbert Riehl, Professor of Atmospheric Science and Dr. V. M. Yevjevich, Professor of Civil Engineering, Colo. State Univ., Fort Collins, Colo.
 - (d) Basic research.
 - (e) The discharge of major western rivers (Colorado, Columbia, Sacramento, Rio Grande) has fluctuations with the order of magnitude of the mean annual discharge itself. These fluctuations are brought about mainly by variations in winter precipitation yield and by variable evaporation. Heavy precipitation may result from seasonal conditions favorable for the recurrence of cyclones over headwater areas; the occurrence of occasional very heavy storms may also be random. On the other hand, high evaporation, requiring weeks of abnormally dry and warm conditions, must be a manifestation of general circulation anomalies of longer duration. The objective of the study is (1) to separate the 'systematic' and 'random' components of the precipitation, and (2) to determine the controls for the systematic anomalies of precipitation and evaporation. Such controls may be deviations of air-sea heat exchange from average in the tropical Pacific, deviations of the Asiatic monsoon circulation from the mean, and departures of strength and location of the Siberian winter cold pool from normal.
- (4113) WEATHER PATTERNS AND CIRCULATION OF THE TROPICS.
- (b) U. S. Weather Bureau.
- (c) Dr. Herbert Riehl, Prof. of Atmospheric Science, Colo. State Univ., Fort Collins, Colorado.
 - (d) Basic.
 - (e) Part of the project deals with hurricanes, another part with general characteristics of weather in the tropics. Hurricane investigation is concerned (1) with the energy cycle of the mature storm, especially the role played by air-sea interaction in maintaining the center; (2) with the balance of forces in these storms and the nature and importance of frictional forces in a fully turbulent vortex; (3) with the formative stage of hurricanes; and (4) with the ocean-air heat exchange and recovery of ocean temperatures subsequent to hurricane passage. Other studies are concerned with the variability of radiative emission from the atmosphere as a function of height; with the thermal modification of air passing over the tropical ocean under various types of general weather conditions; and with the interaction between tropical disturbances of less than hurricane intensity with their environment at large using line integral approaches.
 - (g) Air in the surface layer approaches hurricane centers at much greater inflow angles (up to 45 degrees) than previously thought. As a result, the whole absorption of heat from the ocean, which maintains the core, and the transfer of angular momentum to the ocean, take place in a very short time; this leads to a new examination of transfer processes at the interface and the meaning of the roughness parameter at very high wind speeds. The balance of forces computation has shown that large frictional forces are active throughout the depth of the vortex; the hypothesis is being tested that these are due to vertical rather than lateral turbulence. On radiation, results of over 100 soundings made with the Suomi-Kuhn radiometer show that the long wave emission in the trade wind belt falls far short of that estimated previously in theoretical calculations, and that a heat source due to this type of radiation exists above 30,000-feet altitude.
 - (h) "On the Balance of Forces in Hurricanes," by William M. Gray, Atmospheric Science Reports, Colorado State University. To be published in the Quarterly Journal of the Royal Meteorological Society.
- (4114) GRAVEL FILTER FOR TILE DRAINS.
- (b) Colorado Agricultural Experiment Station.
 - (c) Mr. Norman A. Evans, Agr. Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
 - (d) Applied, experimental.
 - (e) A sand box model is used in which gravel filters may be tested with any aquifer material of interest. Very fine sand of uniform size is now being used. Gravels of non-uniform size distribution similar to "pit-run" material are being tested.
 - (g) A tentative criteria for gravel based on ratio of mean particle size of aquifer to mean particle size of gravel and standard deviation of gravel particle sizes has been developed.
 - (h) "Criteria for Gravel Filter Design," by A. R. Quazi, M.S. Thesis, Colorado State University Library, 1961.
- (4115) EVAPORATION FROM POROUS MEDIA.
- (b) Colorado Agricultural Experiment Station.
 - (c) Mr. Arthur T. Corey, Agri. Engineering Section, Colorado State Univ., Fort Collins, Colorado.
 - (d) Theoretical, experimental.
 - (e) Effect of surface characteristics on evaporation from porous media at or near saturation are studied in controlled environment chamber.

- (g) A 50 percent reduction in evaporation from saturated media is possible if pores in the surface 1/2 inch are larger than the largest pores of the media.
- (h) "Influence of Inorganic Watershed Cover on Moisture Exchange Across the Soil-Air Interface," Progress Report, AE34ATC13, 1961.
- (4116) KREMASTA SPILLWAY MODEL.
- (b) Engineering Consultants, Inc., Denver, Colo.
- (c) Mr. S. S. Karaki, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.
- (d) Laboratory research; applied research.
- (e) The Kremasta Dam is located in Greece. Due to geologic conditions at the dam site it is necessary to construct an earth-fill dam with a side-channel spillway. The model study of the spillway is being conducted to study the spillway approach channel, supercritical chute, flip bucket design and tail water fluctuation at the power plant.
- (4117) SUPERCRITICAL FLOW.
- (b) Experiment Station, Colorado State Univ.
- (c) Dr. V. M. Yevdjovich, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.
- (d) Theoretical, laboratory research; basic research, doctoral.
- (e) This project is planned to be carried out in three stages: (1) Review of the literature with the assessment of the actual status of knowledge in the field of supercritical flows in steep flumes; (2) design of facilities and experiments to be carried out in hydraulic laboratory; and (3) analysis of the experimental results.
- (g) The project started October 1961.
- (4118) HAIL CLOUDS AND THEIR ENVIRONMENT.
- (b) National Science Foundation.
- (c) Dr. Richard A. Schleusener, Assoc. Research Engineer, Colo. State Univ., Fort Collins, Colorado.
- (d) Field investigation; basic research.
- (e) The occurrence of hailstorms is being related to the synoptic environment, using conventional meteorological data, and to the local environment, using radar, and stereo camera pairs to examine the structure of clouds and precipitation region.
- (g) Analysis of data is now being accomplished.
- (h) "Characteristics of Hailstorms in the Colorado State University Network, 1960-61," by Richard A. Schleusener and Lewis O. Grant, Proceedings of the Ninth Weather Radar Conference, pp. 140-145, October 1961.
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- UNIVERSITY OF COLORADO, Department of Civil Engineering.
- (3405) AN EXPERIMENTAL INVESTIGATION OF THE MECHANICS OF AIR ENTRAINMENT.
- (b) National Science Foundation.
- (c) Dr. Warren DeLapp, Dept. of Civil Engrg., Univ. of Colorado, Boulder, Colorado.
- (d) Basic research.
- (e) An experimental investigation of the mechanics of air entrainment into a liquid by agitation of the liquid. The agitator consisted of a series of lattice grids that oscillated vertically in a column of the liquid. The turbulence of the liquid was varied by adjusting the stroke, speed and spacing of the grids. Fluid properties were varied by using different liquids at different temperatures. The relationship of the mean air content with varying turbulence and fluid properties was determined experimentally and the results analyzed by use of dimensional analysis. An equation expressing the mean air content as a function of the viscosity, surface tension, and density of the liquid and the turbulence characteristics was evaluated. In addition photographic studies of the entrainment process were analyzed and a motion picture of the phenomena was produced. Studies were also made of air content and distribution when the liquid surface was at less than atmospheric pressure.
- (g) Results to date have established the relation as described in (e). Photographic studies established a general relationship between bubble size and distribution and significant fluid properties. Results under reduced pressure show no variation in either mean air content or distribution from results obtained under atmospheric pressure.
- (h) "Air Entrainment in Turbulent Liquids," by J. E. Flack, J. Kveisengen and J. Nath, SCIENCE, Vol. 134, pp. 392-393, August 11, 1961.
- "Mechanics of Air Entrainment in Turbulent Fluids," by J. Kveisengen, unpublished M. S. thesis, University of Colorado, August 1961.
- "Whitewater," by J. E. Flack, H. Bjornestad, A. Brinchmann-Hansen and J. Kveisengen, published in January 1961 issue of COLORADO ENGINEER, University of Colorado, Boulder, Colorado.
- (3713) ANALYSIS OF THE CRITICAL FLOW METER FOR MEASURING MASS FLOW RATES OF COMPRESSIBLE FLUIDS.
- (b) The Martin Company, Denver, Colorado.
- (c) Mr. B. T. Arnberg, Mechanical Engineering Department, Univ. of Colo., Boulder, Colo.
- (d) Experimental; applied research.
- (e) The advantages and limitations of the critical flow meter for measuring and controlling compressible flow rates were reviewed. Operating parameters for measuring and correlating flow data were established. Design parameters and meter performance data were studied. A comparison was obtained between water, subsonic air, and critical air flow discharge coefficients.
- (f) First phase of experimental work completed.
- (g) The inlet stagnation pressure and temperature are preferred to static properties, and the throat Reynolds number is preferred to the inlet Reynolds number for the correlation of critical flow data. The elimination of the pressure differential measurement required in variable head meters simplifies the instrumentation required for measuring and controlling compressible flow rates, and also greatly increases the flow range attainable. The large pressure drop required to maintain sonic velocity at the throat is the other main limitation. Dissipative and vena contracta effects control the discharge coefficient versus Reynolds number characteristic for nozzles of varying designs. The divergent section downstream of the nozzle throat, and the throat boundary layer thickness seem to control the effect of back pressure on the critical discharge coefficient, and the unchoking characteristics of the nozzle. The method was shown to be reproducible to better than 0.1 percent. Critical discharge coefficients were within 0.3 percent of sub-sonic and water discharge coefficients at a Reynolds number of 5×10^5 .
- (h) "Review of Critical Flowmeters for Gas Flow Measurements," by B. T. Arnberg, Transactions of the ASME, Journal of Basic Engineering, No. 61-WA-181.
- (3716) A TWO-YEAR RESEARCH PROGRAM ON PAST AND PROBABLE FUTURE VARIATIONS IN STREAM FLOW IN THE UPPER COLORADO RIVER.
- (b) State of Colorado, Office of the Governor.
- (c) Dr. Morris Garnsey, Bureau of Economic Research and High Altitude Observatory,

Department of Economics, University of Colorado, Boulder, Colorado.

- (d) Project is theoretical and is classified as basic and applied research.
- (e) The project is an investigation of the optimum form of information regarding the seasonal and year to year availability of water in a specific watershed, the Upper Colorado River basin. The program involves three aspects: (1) A thorough statistical analysis, utilizing the latest statistical techniques, of the historical records of streamflow and precipitation. A result would be an accurate as possible expression of the probability of occurrence of various levels of precipitation and runoff, together with statistical methods of forecasting, if possible, future runoff amounts. A study of the usefulness of this form of statistical information in optimal basin operation procedures has been made. (2) A broader study embracing correlations between streamflow and meteorological elements in an effort to learn more about hydrometeorological phenomena and to determine to what extent better hydrometeorological knowledge can be relied upon to predict stream flow. (3) A basic research effort into specific aspects of the general circulation of the upper atmosphere, including the finding of possible relations between hemispheric atmospheric circulation patterns and specific meteorological and climatological phenomena in the basin.
- (f) Completed.
- (g) Results can be ascertained from titles of publications below.
- (h) "Past and Probable Future Variations in Stream Flow in the Upper Colorado River," in five volumes. Part I. "Summary and Conclusions," by Morris E. Garnsey, Bureau of Economic Research, University of Colo., October, 1961. Part II. "A Study of the Statistical Predictability of Stream Runoff in the Upper Colorado River Basin," by Paul Julian, High Altitude Observatory, University of Colorado, October, 1961. Part III. "Some General Aspects of Fluctuations of Annual Runoff in the Upper Colorado River basin," by V. M. Yevdjovich, Civil Engineering Section, Colorado State Univ., Fort Collins, Colorado, October, 1961. Part IV. "Probability Analysis Applied to the Development of a Synthetic Hydrology for the Colorado River," by M. R. Brittan, Bureau of Economic Research, University of Colorado, Boulder, October, 1961. Part V. "Analysis of Precipitation Data in the Upper Colorado River basin," by R. A. Schleusener and L. W. Crow, Civil Engrg. Section, Colorado State University, Fort Collins, Colorado, October, 1961.

UNIVERSITY OF CONNECTICUT, School of Engineering.

- (3717) PRESSURE WAVES RADIATED BY A COLLAPSING CAVITY.
- (b) David Taylor Model Basin, Department of the Navy.
- (c) Professor R. S. Brand, Box U-37, Univ. of Connecticut, Storrs, Connecticut.
- (d) Theoretical; basic research.
- (e) The velocity and pressure fields surrounding a collapsing spherical cavity are being computed numerically, with particular attention being given to the spherical shock wave which originates at the point of collapse and moves outward.

CORNELL UNIVERSITY, Agricultural Engineering Department.

- (2521) AN INVESTIGATION OF DRAINAGE PROBLEMS UNDER NEW YORK STATE CONDITIONS WITH SPECIAL EMPHA-

SIS UPON DESIGN PRINCIPLES AND PRACTICES.

- (b) Laboratory project.
- (c) Prof. R. D. Black, Agricultural Engineering Dept. Riley-Robb Hall, Cornell University, Ithaca, New York.
- (d) Experimental; applied.
- (e) The influence of soil structure management upon surface runoff and tile flow is being studied on two natural drainage class soils. Continuous records of surface and tile flow are being obtained as well as soil moisture information at regular intervals.
- (g) Poor soil structure management has resulted in significantly more surface runoff. Most of the data are in process of analysis.
- (4119) INFILTRATION OF WATER UNDER PRESSURE.
- (b) Laboratory project.
- (c) Prof. Gilbert Levine, Agricultural Engrg. Department, Riley-Robb Hall, Cornell Univ., Ithaca, New York.
- (d) Experimental; applied (for doctoral thesis).
- (e) One dimensional flow through columns of porous media and two dimensional flow in a Hele-Shaw model has been studied to determine the feasibility of determining the hydraulic conductivity as saturation in an unsaturated soil.
- (g) Hydraulic conductivity at saturation could be calculated with satisfactory accuracy where a steep wetting front advance was reasonably approximated during the infiltration process. A digital computer solution for the one dimensional flow case was developed.
- (h) "Infiltration of Water Under Pressure From A Piezometer Cavity Into A Homogeneous Soil," by Ido Segner, Ph. D. Thesis, Cornell University, 1961 (available on loan).

(4120) UTILIZATION AND DESIGN IMPROVEMENTS FOR IRRIGATION SYSTEMS.

- (b) Laboratory project.
- (c) Prof. Gilbert Levine, Agricultural Engrg. Dept., Riley-Robb Hall, Cornell University, Ithaca, New York.
- (d) Experimental; applied.
- (e) The influence of moisture stress upon the yield and quality of a number of vegetable crops has been studied upon experimental plots. Associated soil moisture and meteorological measurements are being used to determine moisture extraction patterns and consumptive use data for use in irrigation systems design and operation.
- (g) Data in process of analysis.

CORNELL UNIVERSITY, School of Civil Engineering.

(2285) QUADRANT EDGE ORIFICE STUDIES.

- (b) Laboratory project.
- (c) Prof. Marvin Bogema, School of Civil Engrg., Applied Hydraulic Laboratory, Cornell Univ., Ithaca, New York.
- (d) Experimental.
- (e) Study of the quadrant edge orifice for discharge measurements at low Reynolds numbers. Effect of upstream velocity distribution on meter coefficient.
- (h) "Variation of the Coefficient of Discharge of Quadrant Edge Orifice Installed Downstream of a Well Rounded Entry," by Bradford H. Spring, M.S. Thesis, Cornell University, June 1961.
- "Quadrant Edge Orifice Performance -- Effect of Upstream Velocity Distribution," by M. Bogema, B. Spring and M. V. Ramamoorthy, ASME Paper No. 61-WA-28.

(3719) SHARP EDGE ORIFICE STUDIES.

- (b) Laboratory.
- (c) Prof. Marvin Bogema, School of Civil Engrg.,

Applied Hydraulic Laboratory, Cornell Univ., Ithaca, New York.

- (d) Experimental; M.S. Thesis.
- (e) Study of sharp-edge orifice in 2-inch pipe with Beta ratios 0.3, 0.4, 0.5, 0.6, and 0.7 in the range of Reynolds number from 400 to 8000.
- (h) "The Sharp Edged Orifice -- Operation at Reynolds Numbers less than 10,000," by M. Sivakumar, M.S. Thesis, Cornell University, June 1961.

(4121) TWO-DIMENSIONAL CHANNEL FLOW.

- (b) Laboratory project.
- (c) Dr. J. A. Liggett, Civil Engineering, Cornell Univ., Ithaca, New York.
- (d) Theoretical; basic and applied research (Ph.D. Thesis).
- (e) A study of the equation of two-dimensional, free surface flow is being studied with such effects as frictional resistance and vertical curvature included. Numerical methods using high speed computer are also being studied.

(4122) OPEN CHANNEL PROFILES.

- (b) Laboratory project.
- (c) Dr. J. A. Liggett, Civil Engineering, Cornell Univ., Ithaca, New York.
- (d) Theoretical.
- (e) The equations of steady channel flow are solved by iteration as integral equations. Procedures and examples are given for both hand calculation and calculation by digital computer.
- (f) Completed.
- (h) "General Solution for Open Channel Profiles," by J. A. Liggett, Journal of the Hydraulics Division A.S.C.E., November 1961.

UNIVERSITY OF DELAWARE, Fluid Mechanics Laboratory Section, Dept. of Civil Engineering.

(3720) PROBLEMS OF FREE SURFACE FLOW.

- (b) Laboratory project, flow tank.
- (c) Dr. Kurt Frey, Department of Civil Engrg., University of Delaware, Newark, Delaware.
- (d) Experimental; model testing done as a senior student project.
- (e) The redistribution zones upstream of the test section of the flow tank were studied with two models for achieving satisfactory flow for all principal conditions of operation of the facility.
- (f) Completed. Model tests mainly done by P. Shelton.
- (g) A suitable combination of guide vane systems, screens, and nozzle arrangement has been determined experimentally for the intricate case of flow. The application of the results to the flow tank has resulted in the fully satisfactory flow distribution for the whole range of operations of interest. This refers particularly to the range of flow of 2,000 to 4,000 gpm; flow cross sections at 10 foot long test region at 66 by (6 to 16) inches of width and depths respectively.

(4123) STUDIES ON MECHANICS OF FLUID FLOW.

- (b) Laboratory project for flow tank (3720) in part done in wind tunnel also.
- (c) Dr. Kurt Frey, Professor, Department of Civil Engineering, University of Delaware, Newark, Delaware.
- (d) Experimental. Educational purpose in general and for senior students projects; preliminary studies of tentative research work, development.
- (e) The following topics may be listed. (1) Composite models of configurations of elbows and diffusers including sudden enlargements of two and three dimensions for single and multiple jets; arrangements of such devices

in series and apparatus. (2) Plates and vanes and composite models for flow about objects creating drag or drag and lift. (3) Several methods of boundary layer control in conjunction with items (1) and/or (2) including guide vane systems without and with jet stream formations of different kind; baffles, and groins. (4) Towed models having various degrees of freedom and producing drag or drag and lift. Methods of tracing flows along and exterior to boundaries on the surface and submerged are used and combined with the study of the deformation of the surface level. The scope includes the transition from rest to constant velocity of different magnitudes and also the study of effects of disturbances including rotary motions of the approaching flow as compared to the undisturbed oncoming flow for various model arrangements. (f) Models completed at the presently planned scope; work active. (g) The studies of the mechanics of fluid flow have been considerably improved as compared to those possible with known facilities of the same type. This appears to be of substantial significance in education and development and, particularly, in comprehensive research when an improved understanding of intricate flow phenomena and mastering of such phenomena is desirable and is approachable with free surface flow tank experimentation. (h) Sufficient data of the new flow tank and in comprehensive research have not been taken yet for publication.

UNIVERSITY OF FLORIDA, The Engineering and Industrial Experiment Station, Coastal Engineering Laboratory.

Inquiries concerning projects Nos. 3051, 3412, 3413, 4127, 4128, 4129 and 4130 should be addressed to Dr. Per Bruun, Head, Coastal Engineering Laboratory, University of Florida, Gainesville, Florida.

(3051) BASIC STUDY OF THE RELATION BETWEEN WIND AND WATER BEHAVIOR IN COASTAL WATER.

- (b) National Science Foundation.
- (d) Field and laboratory study; basic research.
- (e) A combined field and laboratory research program analyzing the transfer of energy from wind to water and the effect of sloping offshore profiles as compared with bodies of water with constant depth; study of the combined setup by waves and wind for different standard profiles. Observations will be made on two platforms in the Gulf of Mexico and laboratory experiments will be carried out in the wave tank of the Coastal Engineering Laboratory.
- (f) Field and laboratory tests have been completed.
- (h) Reports and papers in progress.

(3412) FLOOD TIDE STUDY.

- (b) Laboratory project.
- (d) Field investigation; applied research.
- (e) Topography of coastal areas in Florida in relation to potential flooding and statistical analysis of extreme high tides.
- (h) Publication by the University of Florida in print.

(3413) INLET STUDIES.

- (b) Laboratory project.
- (d) Field investigation; applied research.
- (e) Study of the stability of coastal inlets.

(3722) HYDRAULIC MODEL STUDY OF SARASOTA BAY.

- (b) City of Sarasota and Arvida Realty Corp.
- (c) City of Sarasota, Sarasota, Fla.
- (d) Experimental; applied research.
- (e) To study effect of fills in Sarasota Bay on

- the stability of New Pass and Big Sarasota Pass.
- (g) Field investigation and model tests completed.
- (3723) EMERALD BEACH PROJECT, PASCO COUNTY.
- (b) Trustees of Emerald Beach Project.
- (c) Mr. C. C. Edwards, P. O. Box 308, Port Richey, Florida.
- (d) Field investigation; applied research.
- (e) Coastal engineering recommendations for planning of fill project.
- (f) Completed.
- (3724) ANALYSIS OF BEACH PROFILES AT JUPITER ISLAND.
- (b) Mr. Alton A. Register.
- (c) Mr. Alton A. Register
- (d) Field investigation; applied research.
- (e) Recommendations for the establishment of a sea wall line.
- (f) Completed.
- (4124) MODEL STUDY OF EAST HORSENECK BEACH INLET.
- (b) Duffill Associates, Consulting Engineers, Boston, Mass.
- (c) Duffill Associates, Consulting Engineers, Boston, Mass.
- (d) Experimental; applied research.
- (e) Study of wave action in inlet.
- (f) Completed.
- (4125) HYDRAULIC MODEL STUDY OF SAN NICOLAS HARBOR, ARUBA, N.W.I.
- (b) Lago Oil and Transport Co., Ltd., Aruba, N.W.I.
- (c) Lago Oil and Transport Co., Ltd., Aruba, N.W.I.
- (d) Experimental; applied research.
- (e) To investigate wave action and recommend improvements for the harbor.
- (4126) COASTAL ENGINEERING STUDY AT MULLET KEY.
- (b) Pinellas County Park Board, Clearwater, Fla.
- (c) Pinellas County Park Board, Clearwater, Fla.
- (d) Field investigation; applied research.
- (e) Recommendations for protection from beach erosion.
- (4127) FLUORESCENT TRACING OF SEDIMENT IN COASTAL AREAS.
- (b) Department of Health, Education and Welfare.
- (d) Field investigation; basic and applied research.
- (e) Tracing of sand drift on beach and offshore bottom by means of injected fluorescent material.
- (4128) FLUX OF WAVE ENERGY PERPENDICULAR TO THE DIRECTION OF WAVE PROPAGATION.
- (b) National Science Foundation.
- (d) Basic research.
- (e) Experiments to determine flux of wave energy perpendicular to the direction of wave propagation.
- (g) In planning stage.
- (4129) INFLUENCE OF SEA LEVEL RISE ON EROSION.
- (b) State Government.
- (d) Basic field research.
- (e) To determine the influence of short-term as well as long-term fluctuation of sea level on erosion and shoreline movements.
- (h) Publication in progress.
- (4130) EROSION STUDY OF SAND SHORES IN FLORIDA.
- (b) State Government.
- (d) Applied research.
- (e) To check present status of erosion.
- GEORGIA INSTITUTE OF TECHNOLOGY, Hydraulics Laboratory
- Inquiries concerning the following projects should be addressed to Prof. C. E. Kindsvater, Hydraulics Laboratory, School of Civil Engineering, Georgia Institute of Tech., Atlanta, Ga., except as otherwise indicated.
- (291) FLOW OF WATER OVER HIGHWAY EMBANKMENTS.
- (b) Laboratory project.
- (d) Experimental; partly sponsored by U. S. Geological Survey.
- (e) Experimental data were obtained on the discharge characteristics of an embankment-shaped weir. Emphasis has been placed on free discharge over smooth-surfaced embankments. Data have been obtained on the influence of embankment height and tailwater submergence. Detailed velocity surveys have been made to define the boundary layer between the upstream edge of the upstream shoulder and the crown. Tests were made on a 1:9-scale model in a 3-foot wide flume.
- (f) Completed.
- (g) It has been established that the discharge characteristics of an embankment can be related to the theoretical equation of discharge for a broad-crested weir by means of the discharge-displacement boundary-layer thickness. Data and procedures for computing the thickness of the boundary-layer at the control section have been determined as a means of generalizing the discharge equation for various shapes, sizes and roughness of embankments.
- (1331) THE DIFFUSION OF FOREIGN PARTICLES IN A FLUID.
- (b) Laboratory project; sponsored by the National Science Foundation.
- (c) Dr. M. R. Carstens, School of Civil Engrg., Georgia Institute of Technology, Atlanta, Georgia.
- (d) Experimental; basic research for doctoral dissertation.
- (e) The diffusion of macroscopic foreign particles was studied in a diffusion column in order to determine the difference in diffusion of the foreign particles and the fluid. The diffusion mechanism was created by a pattern of pulsing jets. The amplitude and frequency of the pulse of the jets was controlled. The foreign particles were ion-exchange resin beads to which were attached radioactive cesium molecules. Particle concentration within the column was determined by gamma-ray radiation count. Fluid-diffusion characteristics were determined by the diffusion of dye.
- (h) Dissertation in preparation.
- (1584) FLOW OF WATER OVER WEIRS AND SPILLWAYS.
- (b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.
- (d) Library search, re-analysis and correlation of published data, plus original research as required.
- (e) A comprehensive study of the discharge characteristics of practical forms of weirs and spillways, including the preparation of bibliography and the collection and analysis of experimental data from all known sources. Objectives include the publication, in generalized form, of available experimental data.
- (2529) UNIFORM FLOW IN OPEN CHANNELS.
- (b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.
- (d) Reanalysis and correlation of existing data; original experimental research and analysis; theoretical study of turbulence energy transfer and diffusion mechanisms.
- (e) A fundamental investigation of the mechanics

- of uniform flow in open channels, with particular emphasis on the influence of channel shape on velocity distributions and wall shear-stress distributions. Experimental work is being conducted on simple and compound cross sections in a variable slope 90-foot long flume.
- (h) "Resistance Coefficients and Velocity Distribution Smooth Rectangular Channel," by H. T. Tracy and C. M. Lester, Geological Survey Water-Supply Paper 1592-A, 1961.
- 3052) DEZ RIVER DAM SPILLWAYS.
- (b) Resources and Development Corporation.
(c) Dr. P. G. Mayer, School of Civil Engrg., Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental; design.
(e) Two circular shaft spillways are being investigated. The effects of short radius and long radius bends are studied. The hydraulic performance of an inclined shaft spillway is compared with a vertical shaft. The study represents a continuation of previous work.
(f) Completed.
- 3414) INFLUENCE OF FREE-SURFACE DISTURBANCES ON PIEZOMETRIC MEASUREMENTS.
- (b) Laboratory project.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental and theoretical; research for master's thesis; partly supported by U. S. Geological Survey.
(e) Observations on laboratory flume (see proj. 2529) revealed a discrepancy between depth measurements and piezometric-head measurements for flow conditions involving disturbed free surface. The phenomenon appears to be analogous to pressure or density variations in unsteady, compressible-fluid flows.
(h) "Piezometric Measurement of Depth in Open Channels," by W. W. Emmett, master's thesis.
- 3725) SECONDARY MOTION IN ENCLOSED CONDUITS AND OPEN CHANNELS.
- (b) Laboratory project.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Theoretical and experimental; research for Ph.D. thesis.
(e) A fundamental study of secondary motion in turbulent flows. Secondary motions are often superimposed upon flows in enclosed conduits and open channels. The mode of origin, development and decay is being studied to delineate the influence on the general motion pattern in straight, non-circular conduits and channels. The present phase concerns turbulent flow in a non-circular enclosed conduit.
- 4131) FLOW OVER GATED SPILLWAYS.
- (b) Laboratory project; Georgia Power Company.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental, applied research.
(e) Studies are to be made to evaluate discharge characteristics of gated spillways under various operating conditions in a 1:40 scale model.
- 4132) WATER HAMMER IN A PIPELINE CONTAINING CENTRIFUGAL PUMPS.
- (b) Laboratory project, initiated by and equipment supplied by the Georgia Iron Works, Augusta, Georgia.
(c) Dr. M. R. Carstens, School of Civil Engrg., Georgia Institute of Technology, Atlanta 13, Georgia.
- (d) Experimental research for two Master's theses.
(e) An experimental study was conducted with a laboratory pipeline, which contained three centrifugal pumps in series and a valve at the upstream end. Pressure-time records were obtained at three locations for two different flow conditions. The first condition was the establishment of flow following rapid opening of the valve. The second condition was the flow produced by oscillating the valve.
(f) Total experiment work and one thesis (first condition) completed.
(g) It was found that, for the first condition, three major implosions occurred in the pipeline, at the upstream pump, the middle pump, and the downstream pump, consistently in that order. Each implosion was traceable to the decay of a large vapor pocket.
(h) "A Laboratory Investigation of Water Hammer Associated with the Establishment of Flow in a Pipeline Containing Centrifugal Pumps," by C. S. Martin, M.S. thesis, Georgia Inst. of Technology, May 1961, 45 pp.
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- HARVARD UNIVERSITY, Division of Engineering and Applied Physics.
- (4133) SYSTEMS ANALYSIS ON ECONOMICS AND TECHNOLOGY OF ENVIRONMENTAL HEALTH ENGINEERING.
- (b) Department of Health, Education and Welfare.
(c) Dr. Robert P. Burden, 223 Pierce Hall, Harvard University, Cambridge 38, Mass.
(d) Theoretical investigation involving the application of systems analysis techniques to the development of new methodology that may be applied to any large river basin in investigation of the many alternative technical possibilities for treating and controlling waste water sources, for regulating stream flows and for controlling natural purification as an aid in preparation of comprehensive plans for abating pollution and preserving a desirable quality of water in the major river basins of the United States. Alternatively stated, the goal is the application of operations research together with appropriate large-scale computer programs to testing the validity and utility of new methods for designing and operating comprehensive water resource systems with emphasis on problems of water quality management.
Applied research on methodology of design and operation of water resource systems.
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- UNIVERSITY OF IDAHO, Engineering Experiment Station.
- Inquiries concerning Projects Nos. 1895, 3056, 3057, and 3416 should be addressed to Prof. C. C. Warnick, College of Engineering, and for Projects Nos. 1862, 2786, 3416, and 3418 should be addressed to Prof. G. L. Corey, Dept. of Agricultural Engineering, Univ. of Idaho, Moscow, Idaho.
- (1859) INVESTIGATION OF METHODS OF CONTROLLING AND EVALUATING CANAL SEEPAGE.
- (b) Laboratory project; in cooperation with U. S. Bureau of Reclamation.
(d) Experimental and field investigation; basic and operational with master's thesis.
(e) Different types of canal linings are being studied and various ways of evaluating performance are being considered, especially ideas for measuring canal seepage from both lined and unlined canals.
(g) New sealants are being investigated in experimental sections of irrigation canals. Techniques for measuring seepage are being compared in simultaneous testing in by-pass sections of canal.

- (h) "An Investigation of the Use of an Air Permeameter to Measure the In Situ Hydraulic Conductivity of Sandy Soils," by T. L. Anderson, M. S. Thesis, University of Idaho, 1961.
- (1862) DETERMINATION OF ANNUAL RUNOFF FROM WATERSHED CHARACTERISTICS.
- (b) Laboratory project; being carried on under Agricultural Experiment Station.
- (d) Experimental; applied research.
- (e) A study of the hydrological factors affecting the Moscow Mountain Watershed as it applied to the total water use in the area.
- (g) Measurement data on a small watershed is continuing to be collected.
- (2786) FARM IRRIGATION EFFICIENCIES.
- (b) Laboratory project; cooperative with the Bureau of Reclamation under the Agricultural Experiment Station.
- (d) Field investigation; basic and applied research.
- (e) To evaluate irrigation efficiencies on actual farms to aid in planning of a water use on irrigation projects. To consider efficiency from aspect of farm operations and not just consumptive use of crops.
- (g) Basic field data have been collected for 4 years. Final results will be published after one more years record.
- (h) "Irrigation Efficiency Studies," by Carrol Tyler and G. L. Corey, Idaho Agricultural Research Progress Report No. 55, May 1961.
- (3056) TELEMETERING HYDROLOGIC DATA FROM MOUNTAIN LOCATIONS.
- (b) Laboratory project; in cooperation with federal agencies and power companies.
- (d) Laboratory and field investigation; basic and applied operational research.
- (e) A complete system for reporting six or more hydrologic data is being studied and basic parameters of snow melt are being studied for conversion into time delay circuits for transmission by radio.
- (g) Prototype unit is being tested on Moscow Mountain; elements of measurement transducers are being studied both in the field and in the laboratory. License for station has been approved.
- (h) "Automatic Measurement of Hydrologic Parameters at Remote Locations," by L. M. Maxwell, C. C. Warnick, L. A. Beattie, and G. G. Hespelt, Proceedings of the Western Snow Conference, Santa Fe, New Mexico, April 1960.
- (3057) CONSERVATION OF WATER FOR RANGE STOCK.
- (b) Laboratory project; in cooperation with Bureau of Land Management and ranchers.
- (d) Field investigation; applied operational research.
- (e) Experimental stock watering ponds in desert areas will be lined and evaporation control measures supplied to see if extension of such water supply can be developed economically.
- (g) Several ponds lined and unlined are being studied and enonomolecular films are being experimented with to find net water savings. The hydrology of small ponds is also being investigated.
- (h) Progress report to be available on limited basis.
- (3416) STUDY OF METHODS FOR AUTOMATIC MEASUREMENT OF SNOW WATER CONTENT.
- (b) Laboratory project; cooperative with Agricultural Research Service, U. S. Dept. of Agriculture.
- (d) Field investigation; applied research.
- (e) A study is being made of basic methods of measuring snow water content for use in telemetering data from remote mountain locations.
- (g) Five different methods are being investigated in field experiments at mountain locations. Data are being obtained manually and correlated with conventional tube snow measurements.
- (h) "Measurement of Snow Water Equivalent Using Infrared Radiation," by H. Singh, M.S. thesis, University of Idaho, 1961.
- (3417) INFILTRATION AS AFFECTED BY FURROW PARAMETERS AND SOIL VARIABILITY.
- (b) Laboratory project; under investigation in Agricultural Experiment Station.
- (d) Theoretical; basic research.
- (e) To determine the effect of various furrow geometric parameters and soil conditions on infiltration patterns by analogy methods.
- (g) Flow patterns from square, round and triangular shaped furrows in uniform soils have been investigated.
- (h) "Electric Analog Studies on Unsaturated Flow from Irrigation Furrows," by G. L. Corey and D. W. Fitzsimmons. Paper presented at Pacific Northwest Section Meeting of American Society of Agricultural Engineers, Boise, Idaho, October 21, 1961.
- (3418) AUTOMATIC CONTROL OF SURFACE IRRIGATION WATER.
- (b) Laboratory project, under investigation in Agricultural Experiment Station.
- (d) Experimental field investigation; applied research.
- (e) To develop sensing elements which will electrically trip automatic headgates after a field has become irrigated.
- (g) Several elements have been field tested. No element has been developed thus far that is sufficiently sensitive to high soil moisture levels.
- (4134) MEASUREMENT OF TURBULENCE IN PIPE FLOW DOWNSTREAM FROM GRIDS.
- (b) Laboratory project; National Science Foundation Grant.
- (c) G. C. Martin, Chemical Engineering Dept., University of Idaho, Moscow, Idaho.
- (d) Experimental; basic research.
- (e) To measure turbulence in pipes to determine its effects on mass transfer from solids.
- (g) Grids were found to have very little effect on turbulence in pipes.
- (h) "Measurement of Turbulence Downstream of Grids in Pipes," by C. R. Skillern, M.S. thesis, University of Idaho, 1962.
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- ILLINOIS STATE WATER SURVEY DIVISION.
- A list of publications is available upon request; write to Illinois State Water Survey, Box 232, Urbana, Illinois.
- (552) SEDIMENTATION OF ILLINOIS RESERVOIRS.
- (b) Laboratory project; cooperative with Agricultural Research Service, Soil Conservation Service, and University of Illinois Agricultural Experiment Station.
- (c) Mr. R. L. Corinth, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) For design of water-supply reservoirs, measurements of sediment accumulation in lakes in Illinois. Sediment samples are analyzed and complete surveys of watershed soil type, slopes, land use, and conservation practices are made.
- (g) Results show correlation between rate of sedimentation and land use on watershed; results show six factors in explaining sediment deposition: age of lake, capacity-inflow ratio, watershed gross erosion, a watershed shape factor, the density of

- non-incised channels, and a watershed slope factor.
- (h) "Relation Between Reservoir Sediment Deposition and Selected Watershed Variables," presented at the 1961 ASCE Hydraulics Div. Conference.
- (555) EVAPORATION IN ILLINOIS.
- (b) Laboratory project.
- (c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) Measurements are made of evaporation at four stations in northern, central, and southern Illinois. Evaporimeters constructed and installed adjacent to pans for year-round records.
- (h) Measurements published in Climatological Data, Illinois Section. "Lake Evaporation in Illinois," State Water Survey Technical Letter No. 5, 1960.
- (559) ARTIFICIAL RECHARGE OF GROUND-WATER.
- (b) Laboratory project.
- (c) Mr. Robert H. Harmeson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
- (d) Experimental; basic research.
- (e) Model studies of different pit types and variations in relationship between ground-water gradients and artificial recharge.
- (g) Pilot plant pit operation by Water Survey relinquished; laboratory analysis in progress.
- (h) "Artificial Ground-Water Recharge at Peoria, Illinois," by Max Suter and Robert H. Harmeson, Bulletin 48, 1960, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (560) GROUND-WATER INVESTIGATION IN PEORIA, ILLINOIS, DISTRICT.
- (b) Laboratory project.
- (c) Mr. Robert H. Harmeson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
- (d) Field investigation; applied research.
- (e) Continuing evaluation of ground-water resources of the district. Ground-water levels and temperatures are monitored in wells in key locations. Effects of artificial recharge are evaluated. Analyses for changes in composition of ground-water used to trace movement of contaminants as a result of artificial recharge.
- (g) Ground-water conditions substantially improved in past ten years and consistently since the use of four recharge pits was initiated in 1956. One pit in North Field is operated the year-round with nearly complete recovery of the recharged water. Recharge in Central Field arbitrarily limited to cool surface water seasons. Central Field recharge has been reduced because of improved ground-water conditions.
- (561) GROUND-WATER INVESTIGATION IN EAST ST. LOUIS AREA.
- (b) Laboratory project.
- (c) Mr. R. J. Schicht, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) To evaluate the potential yield of the sand and gravel deposits beneath the American Bottoms (East St. Louis area). Ground water levels are measured in more than 200 observation wells, 9 of which are equipped with recording gages. Ground-water pumpage, Mississippi River stages, rainfall, and quality of ground-water data are continuously collected. Maps are being prepared showing the distribution and areal extent of the hydraulic properties, the thickness of the aquifer, and water-table contours. Computations are being made to determine the amount of recharge from precipitation and from induced infiltration of river water, and the amount of subsurface flow from valley walls into the American Bottoms. A geohydrologic model will be devised to simulate the complex aquifer system.
- (h) Summary of basic data on ground-water levels and ground-water pumpage in preparation.
- (1092) HYDROLOGIC CYCLE EVALUATION.
- (b) Laboratory project; cooperative with U. S. Geological Survey.
- (c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) Data from rain gage networks (gathered under another project) together with information from 3 stream gaging stations and 5 ground water-level recorders were collected for use in analyzing storm rainfall-runoff relationships on small watersheds and effect of runoff on water table.
- (f) Completed.
- (h) "Hydrologic Budgets for Three Small Watersheds in Illinois," by R. J. Schicht and W. C. Walton, State Water Survey Report of Investigation 40, 1961.
- (1335) GROUND WATER INVESTIGATION IN THE CHICAGO AREA.
- (b) Laboratory project, in cooperation with Illinois State Geological Survey.
- (c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) Study of variations of natural resources. Investigation of artesian well field with wells 1200 to 2200 feet deep, locally heavily pumped. Study of ground water level recession, interferences, transmissibilities, effect of additional demands.
- (g) Results show the ground water resources in Chicago region are developed from four water-yielding units: glacial drift aquifers, shallow dolomite aquifers, Cambrian-Ordovician Aquifer, and Mt. Simon Aquifer. The Cambrian-Ordovician has been the most highly developed source of large ground-water supplies. Pumpage in deep wells increased from 78.3 mgd in 1958 to 91.7 mgd in 1960. Future ground-water supplies should be taken from the shallow aquifers wherever possible.
- (h) "Water Level Decline and Pumpage During 1959 in Deep Wells in the Chicago Region, Illinois," by W. C. Walton, R. T. Sasman, and R. R. Russell, Circular 79, 1960. "Water Level Decline and Pumpage During 1960 in Deep Wells in the Chicago Region, Ill.," by R. T. Sasman, T. A. Prickett, and R. R. Russell, Circular 83, 1961. "Yields of Deep Sandstone Wells in Northern Illinois," by W. C. Walton and Sandor Csallany, Report of Investigation 43, in press.
- (1865) HYDRAULIC DESIGN OF DROP-INLET SPILLWAY STRUCTURES FOR SMALL RESERVOIRS.
- (b) Laboratory project, in cooperation with Agricultural Research Service, Soil Conservation Service, and Illinois Agricultural Experiment Station.
- (c) Mr. H. W. Humphreys, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Experimental; generalized applied research for development and design.
- (e) To determine the most desirable proportions and shapes of drop-inlet spillway structures that have unique flow characteristics and to develop anti-vortex devices. To provide the necessary information on flow relations and discharge coefficients so that these structures may be economically designed. Initial phases of study concerned with hydraulics of square risers with free discharge. Effect of lip or crest shape and

- anti-vortex devices being studied. Second phase to include the complete spillway. Experimental apparatus constructed and tests are being conducted on the complete spillway. Information is being obtained on discharges, vortex effect on discharge, pressures, a flat plate anti-vortex device, and flow conditions.
- (g) Hydraulics of various types of flow possible in square risers are well defined as well as some of the effect of non-square crest shape. Model tests were performed on a drop-inlet spillway to determine whether or not a metal grating deck placed above the inlet can control vortices. The results of the tests show that gratings do not prevent or control strong vortices.
- (h) "Hood Inlet for Closed Conduit Spillways," by Fred W. Blaisdell, a discussion by Harold W. Humphreys, Proceedings, ASCE, Paper No. 2478, Vol. 86, No. Hy5, May 1960; discussion published in Journal of the Hydraulic Division, Proceedings, ASCE Vol. 87, No. Hyl, January 1961.
- (2532) EVAPORATION RETARDATION.
- (b) Laboratory project.
- (c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field investigation; applied research, design.
- (e) Monomolecular chemical films to retard evaporation from water supply lakes and ponds in Illinois. Laboratory studies continuing on smaller containers.
- (f) Reactivated for summer tests.
- (g) Extensive field testing program arranged during summer of 1961 to test application techniques using soluble packages of chemicals. Results appear favorable and tests will be continued through another summer season.
- (2533) MOISTURE INFLOW STUDY.
- (b) Laboratory project.
- (c) Mr. R. G. Semonin, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Applied research.
- (e) Computation of atmospheric moisture inflow of Illinois and subsequent correlation with precipitation. Moisture and wind data obtained from RACB data.
- (f) Inactive.
- (2534) DENSE RAIN GAGE NETWORK PROJECTS.
- (b) Laboratory project.
- (c) Mr. G. E. Stout, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) Data from four rain gage networks, consisting of 50 gages in 400 square miles, 10 gages in 100 square miles, 54 gages in 550 square miles, and 11 gages in 10 square miles. Studies include: (1) Rainfall variability, (2) frequency of point and areal mean rainfall, (3) area-depth relations, (4) variation of point rainfall with distance; (5) areal representativeness of point rainfall; and (6) reliability of areal mean rainfall estimates.
- (2535) FILTERING THROUGH COARSE MATERIALS.
- (b) Laboratory project.
- (c) Mr. Robert H. Harneson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
- (d) Experimental; basic research.
- (e) Small, coarse media (1/4 - to 3/4-inch) filters are operated at rates comparable to those achieved in field practice. Purpose is to study the effects of coarse media on physical, chemical, and bacteriological properties of recharged water and to evaluate the function of coarse media in protecting aquifer materials.
- (g) Results of former field tests of various sizes of materials are reported in State Water Survey Bulletin 48.
- (2788) METEOROLOGY OF FLOOD-PRODUCING STORMS.
- (b) Laboratory project.
- (c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Applied research.
- (e) Investigation of meteorological conditions associated with flood-producing storms in Illinois to obtain basic data for reliable definition of time and space distribution of such storms and for calculation of probable maximum rainfall.
- (g) Continuing project; analysis of storm area-depth relations, orientation of storms, seasonal and geographic distribution, synoptic weather types, topographic influences. Development of area-depth frequency relations underway.
- (3421) PILOT DRAINAGE BASIN STUDIES IN NAPERVILLE AREA.
- (b) Laboratory project.
- (c) Mr. W. C. Walton, Illinois State Water Survey Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) All factors of the hydrologic cycle (especially precipitation, temperature, stream flow, soil moisture, changes in surface and subsurface storage, and evaporation) to be measured and examined to obtain quantitative knowledge of the movement and storage of ground water under natural conditions in the 22-square mile basin. The annual rate of recharge to, and evapotranspiration from, the ground-water reservoir to be determined. Stream discharge hydrograph to be separated into its two components, surface runoff and ground-water runoff. Gravity yields of glacial deposits and underlying dolomite aquifer to be estimated.
- (3058) HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS.
- (b) Laboratory project.
- (c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field investigation; applied research.
- (e) Field surveys and detailed analyses of severe rainstorms in Illinois. Analyses based upon radar, synoptic weather, and field survey data and include area-depth-duration relations, antecedent rainfall evaluation, isohyetal maps for peak periods of storm.
- (g) Analyses completed on 16 storms since 1951.
- (h) Report of Investigation 42, in press.
- (3059) THERMAL LOADINGS AND CHARACTERISTICS OF SURFACE WATERS.
- (b) Laboratory project.
- (c) Mr. Robert H. Harneson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
- (d) Field investigation; applied research.
- (e) A study of heat loads applied to fresh water bodies in Illinois to determine relationships between temperature and/or heat loadings, water usage, stream assets, and stream recovery capabilities.
- (3419) PRECIPITATION DROUGHT CHARACTERISTICS.
- (b) Laboratory project.
- (c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Applied research.
- (e) Investigation of precipitation drought frequency in Illinois, distribution in space and time of dry periods, relative severity of these periods, meteorological conditions favorable for drought in Illinois, correlation of precipitation drought with other meteorological factors such as thunderstorm frequency and atmospheric moisture distribution, and associ-

- ation of precipitation drought with low stream flow.
- (3420) FREQUENCY AND DURATION OF LOW FLOWS.
- (b) Laboratory project.
 - (c) Mr. John B. Stall, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Theoretical; applied research.
 - (e) Analysis of the severity, frequency, and duration of low flows in Illinois streams. Study of the suitability of various theoretical distributions in explaining the occurrence of these low flow events. A partial series developed for low flow events; this series suitable for low flows from 1 month to 60 months in duration.
 - (g) Gumbel's Extreme Value Law found satisfactory for explaining the occurrence of independent low-flow periods from 1 month to 60 months duration for recurrence intervals from 2 years to 45 years at 20 stream gaging stations in Illinois, varying in drainage area from 550 square miles to 1310 square miles.
 - (h) "A Partial Duration Series for Low Flow Analyses," by John B. Stall and James C. Neill, Jour. Geophys. Res., December 1961.
- (3731) HYDROLOGY OF DOLOMITE AQUIFERS.
- (b) Laboratory project, in cooperation with Ill. State Geological Survey.
 - (c) Mr. W. C. Walton, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Field investigation; applied research.
 - (e) Evaluation of water yielding potential of dolomite aquifer in Illinois from pumping test and specific capacity data is in progress. Statistical analysis of well production data is being made to determine geological controls on aquifer productivity.
 - (g) Frequency graphs were used to determine the role of individual units of a dolomite aquifer in DuPage County, Illinois, as contributors of ground water. The practical sustained yield of the dolomite aquifer was estimated based largely on case histories of heavy ground-water development.
 - (h) Report in preparation.
- (3732) TRANSPIRATION RETARDATION.
- (b) Laboratory project.
 - (c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Laboratory and field investigation.
 - (e) Monomolecular film-forming fatty alcohols are introduced to roots of plants causing the plants to transpire less water than control plants.
 - (g) Extensive field tests being analyzed.
 - (h) "Reduction of Transpiration," by W. J. Roberts, Jour. Geophys. Res., Vol. 66, No. 10, October 1961.
- (3733) EVALUATING WELLS AND AQUIFERS WITH ANALYTICAL METHODS.
- (b) Laboratory project.
 - (c) Mr. W. C. Walton, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Field investigation; applied research.
 - (e) Case histories of ground-water development are being studied to determine if it is possible to evaluate wells and aquifers with analytical expressions by devising approximate methods of analysis based on idealized models of aquifer situations. Geohydrologic boundaries are assumed to be straight-line demarcations and are given mathematical expression by means of the image-well theory. The hydraulic properties of the aquifer and overlying confining beds are considered mathematically by using ground-water formulas. Records of past pumpage and water levels and a digital computer are used to establish the validity of this mechanism to describe the response of aquifers to pumping.
 - (g) Case histories of ground-water development
- have been used to evaluate the practical sustained yields of three aquifers in central Illinois.
- (h) "Evaluating Wells and Aquifers by Analytical Methods," by W. C. Walton and W. H. Walker, Jour. Geophys. Res., Vol. 66, No. 1, October 1961.
- "Ground-Water Development in Three Areas of Central Illinois," by W. H. Walker and W. C. Walton, State Water Survey Report of Investigation 41, 1961.
- (3734) INDUSTRIAL WATER USE IN ILLINOIS.
- (b) Laboratory project.
 - (c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Field investigation; applied research.
 - (e) Determine withdrawal of water by industries in Illinois, with delineation according to kinds of industry, location by area, and sources of supply.
 - (f) Reactivated.
- (4135) CORROSION PREVENTION BY CaCO_3 .
- (b) Laboratory project.
 - (c) Mr. T. E. Larson or H. W. Humphreys, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Experimental.
 - (e) To determine chemical requirements and velocity requirements to provide protective coating in water pipes.
- (4136) SEVERE STORM SINGULARITY STUDY.
- (b) Laboratory project.
 - (c) Mr. S. A. Changnon, Jr., Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Applied research.
 - (e) Investigation of the tendency of severe weather events to occur on preferred dates, the causes of observed tendencies, and the application of the results in defining the probability distribution of severe storms. Elements under study include severe rainstorms, thunderstorms, hailstorms, and tornadoes.
- (4137) DIURNAL DISTRIBUTION OF PRECIPITATION AND RELATED WEATHER ELEMENTS.
- (b) Laboratory project.
 - (c) Mr. S. A. Changnon, Jr., Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Applied research.
 - (e) Investigation of the diurnal distribution of various weather elements on a monthly, seasonal, annual, and geographic basis. Elements under study include rainfall, sleet, hail, tornadoes, thunderstorms, freezing rain, and fog. Results will have many applications in planning outdoor events dependent upon weather conditions, and should provide valuable information on precipitation mechanisms in the atmosphere which produce severe rainstorms and other severe weather events.
- (4138) EVAPOTRANSPIRATION IN ILLINOIS.
- (b) Laboratory project.
 - (c) Mr. D. M. A. Jones, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Applied research.
 - (e) Evaluation of methods for calculating evapotranspiration and assessment of evapotranspiration in northeastern Illinois.
- (4139) PRECIPITATION PATTERNS OVER AND AROUND LOWER LAKE MICHIGAN.
- (b) Laboratory project.
 - (c) Mr. G. E. Stout, Illinois State Water Survey, Box 232, Urbana, Illinois.
 - (d) Applied research.
 - (e) Radar film records are being studied to determine the influence of Lake Michigan on precipitation processes. Pilot studies are underway to develop a radar echo climatology

for an area within a radius of 100 miles of Chicago.

ILLINOIS STATE WATERWAYS DIVISION, Springfield.

(1863) EROSION CONTROL, ILLINOIS SHORE OF LAKE MICHIGAN.

- (b) State of Illinois.
- (c) Mr. Thomas B. Casey, Chief Waterway Engr., Div. of Waterways, Dept. of Public Works and Buildings, 201 West Monroe Street, Springfield, Illinois.
- (d) Field investigation; applied research.
- (e) To obtain and correlate basic data on the several forces and factors involved in erosion processes along the Illinois Shore of Lake Michigan to the end that future efforts toward the prevention of erosion might be founded upon a more definite and factual basis with a consequent greater degree of assurance that the works will serve the intended purposes.

UNIVERSITY OF ILLINOIS, Soil and Water Conservation Engineering Lab., Department of Agricultural Engrg.

Inquiries concerning the following projects should be addressed to Prof. B. A. Jones, 100 Agricultural Engineering, University of Illinois, Urbana, Ill.

(2316) RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

- (b) Laboratory project cooperative with ARS, U. S. Department of Agriculture.
- (d) Experimental and field investigation; basic research.
- (e) To determine frequencies of peak rates and total amounts of runoff from agricultural watersheds of 25 to 1,500 acres; to determine maximum rates of runoff from agricultural watersheds in different soil association areas in Illinois; to compare runoff from agricultural watersheds under accepted soil conservation practices with watersheds cultivated without soil conservation practices. Watersheds of 45.5, 63, 82, and 390 acres near Monticello, Illinois are covered with a rain gage network, and runoff is measured at weirs and spillway structures by water level recorders. Maximum stage recorders are installed at field structures on 8 watersheds in Champaign, Piatt, Vermillion, and Ford Counties on watersheds ranging in size from 45 to 1,400 acres. Model studies and field calibrations are made on the field structures.
- (h) "Water Losses Through Surface Runoff in Central Illinois," by B. A. Jones, Jr. and R. L. McFall, Illinois Research 3-1, (Winter 1961) pp. 8-9.
"Discussion Predicting Storm Runoff on Small Experimental Watersheds," by R. L. McFall and B. A. Jones, Jr., Proceedings ASCE 87 No. HY 2 (March 1961) pp. 196-198.

(2317) A STUDY OF DRAINAGE OF SOME ILLINOIS SOILS.

- (b) Laboratory project cooperative with ARS, U. S. Department of Agriculture.
- (d) Field investigation; applied research.
- (e) To determine on different soil types the effect of tile spacing and depth on (1) water table as measured by drawdown wells, (2) on crop yields; to verify present tile depth and spacing formulas for soil types investigated; and to compare physical laboratory measurements with field measurements. The rate of water table drawdown is measured in wells perpendicular to tile lines. Field permeability and laboratory permeability measurements are made as well as physical analysis of the soil type. Crop yields are

- (f) determined laterally from the tile lines. Discontinued March 1961.

(2789) LABORATORY MODEL STUDIES OF CONSERVATION AND DRAINAGE STRUCTURES.

- (b) Laboratory project.
- (d) Experimental investigation in the laboratory; applied and basic research.
- (e) To investigate the performance of soil and water conservation structures by means of hydraulic model studies, to study water flow patterns into surface drains and to determine the cause of failures and remedial measures of certain conservation structures under flood conditions.
- (h) "The Turbulent Velocity Distribution in Smooth Tubes," by L. F. Huggins, M. S. Thesis, Univ. of Illinois, Jan. 1962 (available on loan).
"A Micro-Differential Pressure Transducer," by L. F. Huggins, in press, Agricultural Engineering.
"Comparison of Theoretical, Laboratory and Field Discharge Ratings of a Drop Inlet for a Small Farm Pond," by J. A. Replogle, L. F. Huggins, and R. D. Black, Paper 61-703, presented at the Winter Meeting of the American Society of Agricultural Engineers, Dec. 1961, (available from the Executive Secretary ASAE, St. Joseph, Mich.).

(3424) A STUDY OF RAINFALL ENERGY AND SOIL EROSION.

- (b) Laboratory project cooperative with ARS, U. S. Dept. of Agriculture.
- (d) Experimental; basic research.
- (e) Natural rainstorms are photographed with a raindrop camera so that the number of raindrops, their size and size distribution, and the kinetic energy of a rainstorm may be calculated. Physical measurements will be made of the soil to determine the effect of the kinetic energy of the rainstorm on soil loss. The nature and properties of rainstorms that occur in this area of Illinois will also be studied.
- (h) "New Design of the Wheel-Type Runoff Sampler," by J. A. Replogle, submitted for publication in Agricultural Engineering.

UNIVERSITY OF ILLINOIS, Civil Engineering Department.

Inquiries concerning all projects should be addressed to Dr. V. T. Chow, Prof. of Hydraulic Engineering, University of Illinois, Urbana, Illinois, unless otherwise indicated.

(564) HYDROLOGY OF URBAN AREAS.

- (b) Laboratory project, cooperative with Ill. State Water Survey.
- (d) Experimental, theoretical, and field investigation; applied research and design.
- (e) Rainfall-runoff study of an urban watershed, having an effective drainage area of 4.45 square miles and a population density of 14 persons per acre. Runoff is measured by a U. S. G. S. stream gage and precipitation by a network of fourteen rain gages strategically located in and out of the watershed. New type of evapornimeter are being developed and check results are being made.

(1591) DETERMINATION OF WATERWAY AREAS.

- (b) Laboratory project, cooperative with Illinois Div. of Highways and Bureau of Public Roads.
- (d) Analytical and field investigation; applied research and design.
- (e) To determine the discharge of water which will reach openings of highway drainage structures, such as bridges and culverts and to provide a simple but scientific procedure for use of engineers in establishing the economical and adequate size of opening. Seven preliminary reports and two field reports have been prepared. A paper entitled

- "Hydrologic Design of Culverts" was presented by V. T. Chow at 1961 ASCE Hydraulics Div. Convention at Urbana, Ill. on August 16, 1961.
- (h) Final report in process of publication.
- (2319) FREQUENCY STUDY OF HYDROLOGIC DATA.
- (b) Departmental study.
- (d) Basic and applied research.
- (e) Application of statistical methods and probability laws to the analysis of hydrologic data.
- (g) A new concept of rainfall intensity frequency is developed and being applied to rainfall data at Urbana and Chicago, Illinois.
- (h) See previous issues of this publication.
- (3060) OPERATIONAL CHARACTERISTICS OF FILTER DRAINS.
- (b) Association of American Railroads.
- (c) Prof. J. C. Guillou, Dept. of Civil Engrg., Univ. of Illinois, Urbana, Illinois.
- (d) Experimental; applied research.
- (e) Investigation of characteristics of flow through granular filters and perforated drain pipe. Laboratory investigations have included tests of coated and uncoated drain pipes, and permeability and filter loss studies using concrete sand as the filter material. Current laboratory investigation is toward determination of operation characteristics with compaction as prime variable.
- (g) Little sorting of filter material occurs at pipe perforations. Filter stability is caused by migration of fines toward the perforation. These particles "bind" the filter and create stability.
- (h) "Second Progress Report on Performance of Filter Materials," by J. C. Guillou and R. F. Lanyon, Report ER-12, AAR Research Center, Chicago, Illinois, May 1961.
- (3425) LOCKPORT SLUICEGATE STUDY.
- (b) Metropolitan Sanitary District of Greater Chicago.
- (c) Prof. J. C. Guillou, Dept. of Civil Engrg., Univ. of Illinois, Urbana, Illinois.
- (d) Experimental, applied research.
- (e) A 1:20 scale model has been constructed and tested. The subject sluiceways will be used for supplemental control of storm water releases from the Chicago Drainage Canal. Three turbine pits in the existing powerhouse at Lockport have been modified to receive triple sluiceways. The model data are being used to develop operational rating data for the gates under various headwater and tail-water conditions.
- (h) Report in preparation.
- (3736) NON-LINEAR APPROACH TO THE INSTANTANEOUS UNIT HYDROGRAPH THEORY.
- (b) Graduate project, doctoral thesis for Mr. K. P. Singh.
- (d) Theoretical; basic research for doctoral thesis.
- (e) To investigate the linearity of the theory of instantaneous unit hydrograph. A mathematical model for the instantaneous unit hydrograph is to be developed and solved by electronic computers. Application of the mathematical model will be made to observed hydrographs.
- (3737) HYDRODYNAMICS OF FREE-SURFACE EFFECT.
- (b) Departmental study.
- (d) Theoretical; basic research.
- (e) To evaluate the free-surface effect of flow in open channels.
- (g) A preliminary study is being made to check the variation in roughness coefficient in circular conduits when the flow is partially full. In this study Prandtl's assumption of constant shearing stress is changed to an assumption of variable shearing stress depending on hydraulic radius. The computed variation in roughness coefficient agrees in general with the average observations.
- (4140) MODEL STUDY OF HYDROGRAPH CONCEPTS.
- (b) Graduate project by G. A. Umamoto and W. H. Huang.
- (d) Experimental, basic research.
- (e) A model watershed of a size of 4 feet by 8 feet with sprinkler system to simulate rainfall is being constructed to verify theoretical concept of unit hydrographs.
- (4141) MODEL STUDY OF SEEPAGE FLOW.
- (b) Graduate project by John Replogle and Robert McFall.
- (d) Experimental, basic research.
- (e) A Hele-Shaw model of 1 ft. by 3 ft. in size, made of plexiglas, is being constructed to verify theories of seepage flow through earth dams and around pumping wells and underdrain.
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- UNIVERSITY OF ILLINOIS, Fluid Mechanics and Hydraulic Laboratory.
- Inquiries concerning Project No. 2083 should be addressed to W. M. Lansford, 219 Talbot Laboratory, University of Illinois, Urbana, Illinois, and for Projects Nos. 2320, 2536, 2537 to Professor J. M. Robertson, 125 Talbot Laboratory, University of Ill., Urbana, Illinois.
- (2083) VELOCITY DISTRIBUTION IN AN OPEN CHANNEL HAVING A TRIANGULAR CROSS-SECTION.
- (b) Laboratory project.
- (d) Basic research.
- (e) Data being obtained from a channel artificially roughened.
- (f) Investigation reactivated, additional data being taken.
- (2536) STUDY OF HOMOLOGOUS TURBULENCE.
- (b) Laboratory project, formerly National Science Foundation.
- (d) Basic research.
- (e) The nature of turbulence (its production and dissipation) is being studied in the simplest possible shear flow. This flow is produced in plane Couette flow where the shear is constant and the turbulence homogeneous but not isotropic. Mean flow studies essentially complete.
- (f) Inactive.
- (2537) WATER EXIT HYDROBALLISTICS.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Basic research; experimental.
- (e) Information on water exit behavior of ellipsoidal bodies of fineness ratios 4 and 8 is being obtained photographically. Water is principal test liquid but glycerine and 100 percent brine solutions have also been used.
- (f) Investigation essentially completed. Some angle-exit experiments not completely analyzed.
- (g) Effects are found to be small, velocity first increases and then decreases as body exits. Significant amounts of water are carried out with the body.
- (h) "The Kinematics of Buoyant-Body Water Exit," by M. E. Clark and J. M. Robertson, Fluid and Solid Mechanics, Vol. 1, Plenum Press, Inc., New York, New York, Proceedings of the 7th Midwestern Conference on Fluid Mechanics held at Michigan State University, September, 1961.
- (3427) STRUCTURE OF TURBULENCE NEAR ROUGH SURFACES.
- (b) Bureau of Ships Fundamental Hydromechanics Research Program.
- (d) Basic research; experimental.
- (e) Information on mean-flow and turbulence structure near roughnesses being studied in an 8-inch "natural roughness" pipe and in 3-inch sand-roughened pipe. Basic question

is how roughness produces turbulence.

(4142) TURBULENT BOUNDARY-LAYER FLOW TOWARDS A NORMAL STEP.

- (b) Graduate project.
- (c) Professor J. M. Robertson, 125 Talbot Lab., University of Illinois, Urbana, Illinois.
- (d) Basic Research.
- (e) An analytical and experimental study is being made of upstream separation, i.e., the real fluid behavior (separation, mixing, reattachment) in front of a normal step projecting inward from a plate along which fluid is flowing with a turbulent boundary layer. Air is fluid medium being used.
- (f) Investigation in process.

(4143) HEMODYNAMICS SIMILITUDE STUDY OF AN ARTERIAL DISTRIBUTION SYSTEM.

- (b) State of Illinois, Department of Public Welfare, Galesburg State Research Hospital, Galesburg, Illinois.
- (c) Prof. M. E. Clark, 123 Talbot Laboratory, University of Illinois, Urbana, Illinois.
- (d) Basic research; experimental.
- (e) The Flow of blood in the Circle of Willis--the arterial distribution system for the brain is to be studied utilizing larger-sized models of both the prototype fluid and conduit system. Present goal is to fabricate a model which will simulate in as many ways as possible the prototype and its flow.

IOWA INSTITUTE OF HYDRAULIC RESEARCH, State Univ. of Iowa.

(66) HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED.

- (b) Cooperative with Department of Agriculture, U. S. Geological Survey.
- (c) Prof. J. W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
- (d) Field investigation; applied research, and M. S. theses.
- (e) Study being made of relation between rainfall and runoff over a small area. Discharge from a 3-square-mile area measured by U. S. G. S.; rainfall records at five automatic recording stations collected by Soil Conservation Service. Continuous records since 1924 of precipitation, runoff, groundwater levels, and vegetal cover.
- (g) Yearly records available for examination at Iowa Institute of Hydraulic Research.
- (h) Reports prepared annually since 1924 available in files at the Iowa Institute of Hydraulic Research. Summary of 33-year record published as Bulletin 16 of the Iowa Highway Research Board in 1961; available upon request from Iowa Highway Commission, Ames, Iowa.

(67) COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA.

- (b) Cooperative with U. S. Geological Survey.
- (c) Mr. V. R. Bennion, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Field investigation; collection of basic stream-flow data.
- (e) Stream-flow and sediment measuring stations maintained throughout the State of Iowa cooperatively on a continuous basis. Records collected by standard methods of U. S. G. S.
- (g) Records of stream-flow and sediment discharge computed yearly.
- (h) Records contained in Water-Supply Papers available through offices of the Geological Survey.

(68) HYDROLOGIC STUDIES, RAPID CREEK WATERSHED.

- (b) Cooperative with U. S. Geological Survey.
- (c) Mr. V. R. Bennion, Iowa Institute of Hydraulic

Research, Iowa City, Iowa.

- (d) Field investigation; applied research.
- (e) Study being made of relation between rainfall and runoff over a small area. Discharge from a 25-square-mile area measured and flood runoff on main subbasins determined by U. S. Geological Survey; rainfall records at four automatic recording stations collected by U. S. Weather Bureau. Continuous records since 1941 of precipitation, runoff, and ground-water levels.
- (g) Rainfall records published in Weather Bureau Climatological Bulletins and surface runoff and ground-water levels published in Geological Survey Water-Supply Papers.

(73) MEASUREMENT OF TURBULENCE IN FLOWING WATER.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental and theoretical; basic and applied research.
- (e) Instruments, primarily electrical in operation, are being developed to measure the characteristics of turbulent flow under a wide range of laboratory and field conditions. Both sensing and computing elements are involved.
- (g) Both hot-wire and thermistor techniques are being used, with the latter proving better for long-term stability where its slow response is not a serious limitation. Commercial pressure cells connected to Pitot tubes have also proved to be useful.
- (h) "A Transistorized Constant-Temperature Hot-Wire Anemometer and Linearizing Circuit," by John R. Glover, M. S. thesis, State Univ. of Iowa, August 1961. (Available on loan.)

(79) CAVITATION.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental and theoretical; basic research and graduate theses.
- (e) Basic information is sought on cavitation for systematically varied boundary conditions. Studies of cavitation behind disks and plates is being continued.

(81) MATHEMATICAL ANALYSIS OF PRESSURE DISTRIBUTION.

- (b) Cooperative with Office of Naval Research and David Taylor Model Basin, Department of the Navy.
- (c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Applied research.
- (e) Pressure and velocity distributions on a series of 30 bodies of revolution, in axial, transverse, and rotational motion are being analyzed.
- (f) Phase described in (e) completed.
- (g) Computer program for obtaining flow patterns developed. Report near completion.
- (h) "Potential Flow About a Family of Bodies of Revolution," by L. Landweber and Matilde Macagno. Final report on Contract N600 (167)55727(x) to the David Taylor Model Basin December 1961.

(1875) CHARACTERISTICS OF STABLE EDDIES.

- (b) Laboratory project, partially supported by Office of Naval Research, Department of the Navy and U. S. Army Research Office (Durham).
- (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental and analytical; basic research.
- (e) Distributions of velocity, pressure, and turbulence are being investigated throughout the vicinity of separation zones produced by abrupt changes in flow section, to the end of establishing the primary eddy characteristics as functions of the boundary geometry.

- (g) Studies are being conducted on flow in the wake of a circular disk and in axisymmetric conduit expansions.
- (h) "Energy Transformation in Zones of Separation," by Hunter Rouse, IAHR Convention, Dubrovnik, 1961.
- (2091) RESEARCH ON SHIP THEORY.
- (b) Cooperative with Office of Naval Research, Department of the Navy and Society of Naval Architects and Marine Engineers.
- (c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental and theoretical; basic research.
- (e) To determine the laws governing the forces, moments, and motions of ships in smooth and disturbed seas, in order to furnish design data to the naval architect. Work is under way on the following problems: (1) Wave damping of a series of rolling (Ursell) cylinders. (2) resolution of viscous and wave drag by means of measurements in the wake of a ship. (3) effect of a free surface on separation. (4) treatment of vibration of spheroids and shiplike forms on the basis of a unified theory of hydroelasticity. (5) mechanism of lift on bodies of revolution and (6) image of a source in a prolate spheroid.
- (h) "Kinetic Energy of a Liquid Surrounding a Prolate Spheroid Vibrating at Its Free Surface," by Enzo Macagno and Matilde Macagno, Journal of Ship Research, Vol. 4, No. 4, March 1961.
- "Drag Coefficients of Flat Plates Oscillating Normally to Their Planes," by M. Ridjanovic, submitted for publication by Schiffstechnik.
- "Separation of Viscous from Wave Drag of Ship Forms," by Jin Wu, submitted for publication to Journal of Ship Research.
- "Ship Motions (Katchka Korablia)," by Blagoveshchensky, published by Dover Publications, Inc., 1961.
- (2324) ANALYSIS OF FLOW PATTERNS FOR SHARP-CRESTED WEIRS.
- (b) Laboratory project, partially supported by National Science Foundation.
- (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Analytical; basic research for doctor's degree.
- (e) Determination of streamline configuration through use of digital computer for various relative heights of weir.
- (f) Approximate solutions now at hand, but final refinements still to be accomplished.
- (2328) INVESTIGATION OF SURFACE ROUGHNESS.
- (b) Cooperative with U. S. Geological Survey, Dept. of the Interior.
- (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental; basic research for doctoral dissertation.
- (e) Primary purpose is to determine the effect of different concentrations of roughness elements on open-channel resistance. Tests have been conducted in two flumes, 30 feet and 65 feet, in both the subcritical and supercritical regimes using a cubical roughness element varying systematically from zero to unity concentration. The correlation between free-surface instability, increased channel resistance, and the presence of roll waves has also been studied.
- (h) "Flow in Artificially Roughened Channels," H. J. Koloseus, and Jacob Davidian, U. S. Geological Survey Professional Paper 424-B, pp. B25-B26.
- "Surface Resistance as a Function of the Concentration and Size of Roughness Elements," by J. A. Roberson, Ph. D. thesis, State Univ. of Iowa, August 1961. (Available on loan.)
- "The Role of the Froude Number in Open-Channel Resistance," by Hunter Rouse, H. J. Koloseus, and Jacob Davidian, Ninth Convention of International Association for Hydraulic Research, Seminar B, pp. 12-13, Dubrovnik, Sept. 4-7, 1961.
- (2541) DEVELOPMENT OF INSTRUMENTS FOR USE IN ANALYZING APERIODIC SIGNALS.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental; applied research.
- (e) The purpose is to improve the analysis of turbulent velocity and pressure fluctuations.
- (g) The control principles used in analog computers are being utilized to obtain better accuracy, more dependability, and for adapting to automatic data reduction by machines.
- (2791) MIXING IN STRATIFIED FLOW.
- (b) Cooperative with the U. S. Army Research Office (Durham).
- (h) "Interfacial Mixing in Stratified Flow," Enzo Oscar Macagno and Hunter Rouse, Journal of Engineering Mechanics Division, ASCE, Vol. 87, No. EM5, October 1961.
- (2792) THE DECAY OF TURBULENCE IN A ZERO-MOMENTUM WAKE.
- (b) Cooperative with the Office of Naval Research Department of the Navy.
- (c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Primarily experimental; basic research.
- (e) Powered models of a strut-mounted propeller and a merchant vessel are driven in a towing basin, and the wake is investigated with a Pitot rake and a hot-wire anemometer.
- (g) Fluctuations in the elevation of the free surface have been found to play an important role, so that it has been necessary to measure local pressures as well as stagnation pressures in the wake.
- (2795) PREDICTION OF RUNOFF FREQUENCY FROM PRECIPITATION AND INFILTRATION FREQUENCIES.
- (b) Laboratory project.
- (c) Prof. J. W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
- (d) Statistical.
- (e) Exploration of possibility of estimating frequencies of rare floods based on combination of observed frequencies of precipitation and infiltration.
- (f) First phase completed; continuing.
- (g) Good correlation for a small, a medium, and a large watershed found in first phase.
- (h) Results to be incorporated in thesis by Srinivasan Mukundan.
- (3068) DETERMINATION OF DYNAMIC FORCES ON FLASH-BOARDS.
- (b) Laboratory project.
- (c) Prof. J. W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
- (d) Experimental; for M. S. thesis.
- (e) Measurement by dynamometer of moment exerted by water flowing over flashboard.
- (g) A parameter involving turning moment on flashboard related to head- and tail-water levels for typical O-G spillway crest.
- (h) Experimental work completed. Results being incorporated in thesis by Alberto Lizarralde.
- (3074) WAKE OF ZERO MOMENTUM FLUX.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (c) Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental; basic research.

- (e) Distribution of velocity, mean and turbulent, and of pressure is being measured in the field of flow past a bluff, axisymmetric body with a centrally located jet for the particular condition of zero momentum flux.
- (3428) MECHANICS OF BANK SEEPAGE IN NATURAL STREAMS DURING FLOOD FLOWS.
- (b) Laboratory project.
 - (c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
 - (d) Field investigation; basic research for Ph. D. thesis.
 - (e) Observations taken on transverse profile of ground-water levels during rise and recession of hydrographs. Sections on Missouri, Des Moines, Boone, Iowa, and English Rivers, Clear Creek and Rapid Creek. Permeability tests made by pumping wells.
 - (g) Early results indicate substantial flow into banks during period of rise, thus showing a negative groundwater contribution to the flow in this period.
- (3429) JET WITH TRANSVERSE PRESSURE GRADIENT.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
 - (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental and theoretical; basic research.
 - (e) In order to better understand the effect of jet mixing on an annular jet, the diffusion of a two-dimensional jet directed against a flat plate in the presence of a transverse pressure gradient has been studied.
 - (h) Final report in preparation.
- (3431) SEDIMENT SORTING.
- (b) Partially supported by National Science Foundation.
 - (c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental; basic research.
 - (e) To determine the effect of various particle-size distributions with the same means but different standard deviations on (1) total-load and suspended-load transportation, (2) bed configuration, and (3) size distribution of the total load.
- (3432) ACCELERATED MOTION OF A SPHERE FALLING IN AN OSCILLATING FLUID.
- (b) Laboratory project.
 - (c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental and analytical; basic research and Ph. D. dissertation.
 - (e) To determine accelerated motion of a sphere falling in an oscillating fluid.
- (3738) SEDIMENT DIFFUSION.
- (b) Laboratory project partially supported by a grant from Gulf Research and Development Co.
 - (c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental; Ph. D. dissertation.
 - (e) To determine the sediment-diffusion characteristics for small concentrations of particles in a submerged jet of water.
 - (h) "Exploratory Study of Sediment Diffusion," by Lucien M. Brush, Jr., Trans. Amer. Geophys. Union, in press.
- (3739) EDUCATIONAL FILMS ON THE MECHANICS OF FLUIDS.
- (b) National Science Foundation.
 - (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (e) Six 20-minute sound films in color are planned to cover following material: (1) An introduction to the subject, stressing its great breadth of coverage, the necessarily
- close tie between theory and experiment, the role of the scale model in engineering analysis and design, and methods of flow measurement in laboratory and field. (2) The source and significance of the fundamental principles of continuity, momentum, and energy, and their application to typical problems in many professional fields. (3) Gravitational phenomena, including jets, nappes, channel transitions, waves, surges, and effects of density stratification. (4) Effects of viscosity, examples of laminar flow, characteristics of fluid turbulence, and problems of surface resistance. (5) Profile drag and lift, and their application to propulsion and fluid machinery. (6) Compressibility effects - water hammer, submarine signaling, gravity-wave and sound-wave analogies, and supersonic drag.
- (g) First film of series, "Introduction to the Study of Fluid Motion," now available from Bureau of Audio-Visual Instruction, Extension Division, State University of Iowa, Iowa City, Iowa.
 - Second film, "Fundamental Principles of Flow," in preparation.
- (3740) HYDRODYNAMICS OF FLUIDS UNDER CONDITIONS OF RAPID ACCELERATION.
- (b) Rock Island Arsenal, U. S. Army.
 - (c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Theoretical and experimental; basic research.
 - (e) Analytical techniques which are applicable to systems involving rapid acceleration of fluids through constructions or of solids through fluids. Results will be expressed as lumped-constant parameters similar to those used for steady-flow phenomena.
 - (g) The dimensionless drag coefficient of a disk was found to increase with acceleration, as was expected. Systematic experiments on orifices are underway, utilizing a blow-down apparatus which was perfected during the year.
 - (h) "Pressure Wave Analysis for Variable Length of a Fluid Column," E. O. Macagno and Matilde Macagno, IAHR Convention, Dubrovnik, 1961.
- (3741) MODEL TESTS OF ROCK SAUSAGES.
- (b) Graduate project.
 - (c) Prof. Posey, Engrg. Bldg., Iowa City, Iowa.
 - (d) Experimental; applied, for M. S. thesis.
 - (e) Tests of model rock-sausage embankment protection to determine maximum safe heads.
 - (f) Completed.
 - (g) With properly installed protection, maximum obtainable head of 17 times sausage diameter would not cause failure. Installation defects that could result in failure were identified.
 - (h) "Erosion Tests of a Protected Embankment Section," by Ki-Shun Chu, M. S. thesis, State University of Iowa, June 1961. (Available on loan.)
- (4144) OUTLET CHANNEL ENLARGEMENT TO INCREASE DISCHARGE.
- (b) Graduate project.
 - (c) Prof. C. J. Posey, Engineering Building, Iowa City, Iowa.
 - (d) Theoretical.
 - (e) Scope of studies by Chuan Chung Chang (M. S. thesis, February 1957) on economy of outlet enlargement will be extended with the aid of a digital computer.
 - (g) Most economical transition found so far consists of a simple horizontal section. Empirical expressions have been formulated to give increase in discharge for a given amount of deepening.
- (4145) INTERFACIAL EFFECTS IN FLUID WITH DENSITY STRATIFICATION.
- (b) Cooperative with the U. S. Army Research

- Office (Durham).
- (c) Dr. Enzo O. Macagno, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental; basic research and graduate thesis.
 - (e) Instability of two-layered flow and subsequent mixing. Effect of thickness of inter-layer on instability. Effect of stratification on turbulence propagation. Role of interfacial shear in stable stratified flow.
- (4146) EFFECT OF GATE LIP SHAPE UPON DOWNPULL.
- (b) Laboratory project.
 - (c) Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental; applied, for M. S. thesis.
 - (e) Pressure distribution under high-pressure gates is being measured for various lip shapes. Coefficients are to be established for the analysis of vertical forces acting upon the gate.
- (4147) RESISTANCE OF CYLINDRICAL PIERS IN SUPERCRITICAL FLOW.
- (b) Laboratory project.
 - (c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental, M. S. thesis.
 - (e) Drag is studied as function of Froude number, relative depth, and relative spacing of piers.
- (4148) MEAN-FLOW AND TURBULENCE CHARACTERISTICS OF RIVER BENDS.
- (b) Supported by the National Science Foundation.
 - (c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Experimental; basic research.
 - (e) To determine the mean-flow and turbulence characteristics of flow in a model river bend. Pressure, velocity, and shear stress measurements are to be made in the curved channel for smooth, rough, and movable beds.
- (4149) DRAG OF SUPERCAVITATING BODIES OF REVOLUTION.
- (b) Bureau of Ships, Office of Naval Research.
 - (c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
 - (d) Theoretical; applied research.
 - (e) Method of computing pressure distributions on supercavitating bodies of revolution being developed. Existing data on pressure distribution being analyzed for drag.
 - (g) Computer program for a proposed method of computing pressure distributions is being evaluated.
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IOWA STATE UNIVERSITY, Department of Agricultural Engineering.

Inquiries concerning the following projects should be addressed to Dr. H. P. Johnson, Department of Agricultural Engineering, Iowa State University, Ames, Iowa.

- (2330) DEPTH, SPACING AND HYDRAULICS OF TILE DRAINS.
- (b) Laboratory project.
 - (d) Theoretical and field investigation; basic and applied research; master's and doctor's thesis.
 - (e) Analytical and experimental approach is being studied to determine depth and spacing of tiled drains by analyzing soil characteristics and geometry of systems. Work is cooperative with Dr. Kirkham, Soil Physics Department of Agronomy. Studies of the relationship of hydrologic and applied hydraulic problems of field tile systems being made.
 - (g) A study of similitude of unsteady flow through porous media was relatively successful and indicated that further investigations

would be profitable.

- (h) "Models of Unsteady State Flow in Porous Media Applied to Soil Drainage," James T. Ligon, Ph. D. thesis, Iowa State University, November 1961. (Available on loan).
- "Operational Characteristics of the Laterals Near the Edge of a Tile Drainage System," by B. L. Grover, J. T. Ligon, and D. Kirkham, J. Geophysical Research 65:3733-3738. 1960.

(2331) SURFACE RUNOFF FROM AGRICULTURAL WATERSHEDS.

- (b) Laboratory project.
- (d) Theoretical; applied research; doctoral thesis.
- (e) A study designed to obtain frequencies of runoff for different soils, moisture conditions and cover is in progress. The elements of point rainfall intensity, infiltration rates, and the unit hydrograph are being integrated in such a form that most of the work involved in finding the frequencies of flow can be done with an electronic computer.
- (g) Study in progress.
- (h) "Interrelationships of Watershed Characteristics," by D. M. Gray, J. Geophysical Research 66:1215-1223. 1961.
- "Synthetic Unit Hydrographs for Small Watersheds," by D. M. Gray, Proc. ASCE Vol. 87, No. HY4, July, 1961.

(2333) IMPROVEMENT OF SURFACE DRAINS WITH TILE BLIND INLETS.

- (b) Laboratory project.
- (d) Field investigation; design.
- (e) Field study is being continued to determine the effect of different tile backfill material on the flow of water into the tile drains.
- (g) Results indicate that the soil placed over the filter material around a tile is very dominant in controlling the movement of ponded water into the tile.

(2334) RUNOFF FROM SMALL WATERSHEDS.

- (b) Laboratory project, cooperative with ARS, USDA.
- (d) Field investigation; applied research design.
- (e) Measurements of rainfall and surface runoff being made on seven agricultural watersheds.
- (g) Bulletin summarizing ten years of record being written.

(4150) COMPARISON OF SYNTHETIC UNIT GRAPH METHODS.

- (b) Laboratory project, Master's Thesis.
- (d) Experimental, applied research; master's thesis.
- (e) Three synthetic unit graph methods developed for application to small watersheds are being compared with actual unit graphs from given watersheds. The effect of duration of storm, and distribution of rainfall with time on the storm hydrograph is being studied.

THE JOHNS HOPKINS UNIVERSITY, Applied Physics Lab.

(2335) APPLICATION OF SWITCHING TECHNIQUES TO HYDRAULIC CONTROL SYSTEMS.

- (b) Bureau of Weapons, Department of the Navy.
- (d) Theoretical and experimental; applied development and design.
- (e) Study the dynamic qualities of an acceleration switching hydraulic servomechanism while operating in a closed loop under the presence of various loads and environmental conditions on the transfer valve, actuator and feedback transducer.
- (g) The operation of a broad bandpass servo-mechanism driving a low resonant frequency linkage has resulted in radial design

compromises to prevent instability. Extension of acceleration switching techniques without any mechanical modifications has permitted closed loop operation with band-passes equal to or exceeding the linkage characteristics.

(3207) ACCELERATION SWITCHING HYDRAULIC SERVOMECHANISMS UNDER EXTREME ENVIRONMENTAL CONDITIONS.

- (b) Bureau of Weapons, Department of the Navy.
- (d) Experimental; applied development and design.
- (e) Extend to regions of extreme high temperature a servomechanism capable of high performance and horsepower (up to 10 H.P.). The servo valve, actuator and feedback transducer must operate under environmental extremes while the electronic circuitry is maintained in a protected area.
- (g) Tests have been conducted on hydraulic servo components under steady state temperature conditions of 700 degrees F ambient and 500 degrees F oil temperature. Thermal shock temperature tests have been conducted on servo packages to 400 degrees F to study transient temperatures.
- (h) "Hydraulic (Acceleration Switching) Servo Dynamic Performance Under Extreme High Temperature Environment," APL/JHU CF-2737, by W. Seamone and K. Duning.
"APL/JHU High Temperature Test Laboratory," APL/JHU CF-2837, by M. Shandor.

(3435) HYDRAULIC SUPPLY LINE CHARACTERISTICS.

- (b) Bureau of Weapons, Department of the Navy.
- (d) Theoretical; experimental.
- (e) High performance hydraulic servomechanisms can excite the pressure and return lines into pressure oscillation. Establishment of the physical relationship which could cause pressure oscillation as well as performance deterioration in the servo valve performance is being investigated.
- (f) Continuing low priority research study.
- (g) The switching activity of an acceleration switching hydraulic servomechanism was noted to create pressure oscillation under specified conditions in length of supply lines. Analysis and experiments have shown that pressure oscillations occur when the acoustic frequency of the hydraulic fluid column is in specific relationship to that of the switching frequency. Where line length changes cannot be used, methods of detuning the supply lines by volume chamber or acoustic filter is developed.
- (h) "A Study of the Influence of the Dynamic Properties of the Inlet Fluid of the Stability Characteristics of an Acceleration Switching Hydraulic Servo," APL/JHU CF-2818, by W. D. Mark, G. A. Levine and W. Seamone.
"Application of Acoustical Filter Theory to Hydraulic Supply Lines," APL/JHU CF-2831, by Sheldon B. Cousin.

(3436) ADAPTIVE ELECTRO HYDRAULIC SERVOMECHANISMS.

- (b) Bureau of Weapons, Department of the Navy.
- (d) Theoretical and experimental.
- (e) Techniques have been developed for designing linear servomechanisms with a limit cycle instability about a relay type non-linearity. The closed loop characteristics of this servomechanism becomes invariant to any pure gain changes occurring in the linear elements. This servomechanism, categorized as a self-oscillating control servomechanism, appeared to be an evolutionary improvement over the acceleration switching hydraulic servo-mechanism.
- (g) A self-oscillating rate servomechanism has been operated with the loop closed around the valve spool position. Predictable self-oscillation frequency was achieved and dynamic performance bandpass was independent of hydraulic supply pressure between 500

and 2000 psi. The bandpass of both servo-mechanisms exceeded 60 cycles per second with the latter operating a complex mechanical load system.

- (h) "Investigation of a Non-linear Electro Hydraulic Power Servomechanism Operating in the Self-Oscillating Control Mode," APL/JHU BBC-5-799 or University of Maryland, Dept. of Mechanical Engineering Thesis, M.S., by G. A. Levine.
"A Self-Oscillating Adaptive Hydraulic Servo," APL/JHU CF-2901, by C. H. Sprague.

THE JOHNS HOPKINS UNIVERSITY, Department of Sanitary Engineering and Water Resources, School of Engrg.

Inquiries concerning the following projects should be addressed to Dr. John C. Geyer, Chairman, Dept. of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore 18, Maryland.

(856) HYDROLOGY OF STORM DRAINAGE SYSTEMS IN URBAN AREAS.

- (b) Baltimore City, Baltimore County, Maryland State Roads Commission, and the U. S. Bureau of Public Roads.
- (d) Field investigation; basic research and design.
- (e) Study of rainfall and runoff relationships as affected by various drainage area parameters. At present, runoff from 6 urban areas ranging in size from 10 to 150 acres are gaged, 5 by stage instruments and 2 by Parshall Flumes. Three recording systems which simultaneously record rainfall and runoff from 12 inlet areas provide good opportunity for detailed study. About 10 years of rainfall records now exist for a network of 12 recording gages covering an area of 50 square miles.
- (g) A study of the Baltimore rainfall data for the period 1894-1955 shows: (1) The critical storm in the Baltimore area is the summer type cloud burst. About two-thirds of the storms - greater than 2 year frequency occur in the months of July and August. Winter storms are not important for design purposes. (2) The maximum average rainfall rate (for durations up to 60 minutes) generally occurs at the beginning of the storm. (3) Rainfall intensities (during 15, 30, and 60 minute durations) for frequencies greater than 2 years are not uniform. Difference between maximum intensity and average intensity over the duration range from 30 percent (for the 15 mile duration) to 75 percent (for the 60 minute duration). Intensities greater than those indicated by rainfall frequency curves occur during more than half the period of the 15, 30 and 60 minute durations studied. Consequently the design storm assumed in the Rational Method is unrealistic. (4) Gagings made by this project and by the Corps of Engineers indicate that where a check on the Rational Method is possible, the Rational Method produces inconsistent results. Further analyses are continuing.
- (h) "Progress Report on the Storm Drainage Research Project, June 1961," by John C. Schaake, Department of Sanitary Engineering and Water Resources, The Johns Hopkins Univ., Baltimore 18, Md. A limited number of copies are available on request.

(3437) RESIDENTIAL WATER USE RESEARCH PROJECT.

- (b) Federal Housing Administration.
- (d) Field investigation; applied research and design.
- (e) This project is directed toward obtaining data on maximum hourly demands in residential areas having varying populations. It also is directed toward obtaining information on the effect of lawn sprinkling and other large water uses on maximum demands.

The purpose of the project is to obtain a rational design criteria for water distribution systems.

- (g) Peak demands in residential areas can be described mathematically based upon statistical evaluation of field data. Peak demands can be determined by segregating residential water use into (1) domestic or short duration uses and (2) lawn sprinkling or long duration uses. The average consumption and the rate of sprinkling per residence increases according to size of lot. The probability of occurrence of sprinkling demands varies with the season and climate and the time of day; while the probability of occurrence of domestic use varies with the number of persons per home and the time of day. The characteristics of the total demand on a distribution system serving residential areas have been tentatively established. Correlation of residential demands with sewage flows, and seasonal and climatic factors is the subject of continuing investigation. The data on water demands of commercial establishments associated with residential areas shows that peak commercial uses frequently are not imposed on sprinkling demands and consequently are situated favorably on the hydrograph of peak daily demands.
- (h) "Progress Reports Nos. 1 and 2 on the Residential Water Use Research Project," John C. Geyer, Jerome B. Wolff and F. P. L. Linaweaver, Jr., October 1960.
"Peak Demands in Residential Areas," Jerome B. Wolff, Journal AWWA, 53: 1251 Oct. 1961.

(3438) RESIDENTIAL SEWERAGE RESEARCH PROJECT.

- (b) Federal Housing Administration.
- (d) Field investigation; operation and design.
- (e) Examination of adequacy and utility of residential sewerage system design criteria. Determination of the effects of parameters of design, construction, loading, and natural phenomena on operation of sewerage systems. Research includes analysis and study of representative sewerage systems throughout the country.
- (g) Sewage flow records presently being compiled from four representative residential areas. The minimum duration of flow study in each area is one year. Operation and maintenance investigation will provide correlations of cause and frequency of sewer stoppages with sewer slope, length of lateral behind stoppage, size of pipe, type of joint material, frequency of cleaning; and maintenance and operating costs of lift stations. The results of sewer stoppages in Springfield, Missouri, are presently being analyzed.
- (h) Residential Sewerage Research Project Progress Reports 1, 2, 3, 4.

UNIVERSITY OF KANSAS, Dept. of Engrg. Mechanics.

Inquiries concerning projects Nos. 3081, 3742, 3743, 3744, 4151 and 4152, should be addressed to Dr. David W. Appel, and projects Nos. 3745, and 4153 should be addressed to Dr. Y. S. Yu, Dept. of Engrg. Mechanics, Univ. of Kansas, Lawrence, Kansas.

(3081) DIFFUSION OF A JET FORMED AT AN ABRUPT ENLARGEMENT IN TWO-DIMENSIONAL FLOW.

- (b) Tennessee Valley Authority, Norris, Tenn.
- (d) Experimental; basic research.
- (e) Further observations of vortices generated along surfaces of separation at abrupt expansions are being made. The effect of vibration of the lip of the expansion and of externally generated pressure variations on the rate of vortex shedding in both cavitating and non-cavitating flows is under investigation.
- (g) The frequency of generation of vortices at abrupt expansions has been measured for

cavitating and non-cavitating flows. In the absence of cavitation, vortices have been found to be unstable and to break down into vortex loop and to rapidly degenerate into turbulence.

- (h) "Vibration Problems in Hydraulic Structures," by Frank Campbell; discussion by David W. Appel and Charles L. Sanford in Jour. of Hyd. Division, ASCE, No. HY-6, Nov., 1961.
"A Study of Vortices Along Surfaces of Separation," by Charles L. Sanford, M.S. Thesis, The University of Kansas, Lawrence, June, 1961.

(3742) DIVERSION OF FLOW WITH SUCTION APPLIED TO SLOTS BENEATH A SHALLOW STREAM HAVING A FREE SURFACE.

- (b) Kimberly-Clark Corporation and the Dept. of Engineering Mechanics.
- (d) Theoretical and experimental; basic research; also master's thesis.
- (e) Experimental verification of a momentum analysis for the drainage into an inclined slot with resistance imposed by a moving screen is sought.
- (g) Approximations used in the momentum analysis were found to result in a maximum departure of 25 percent from experimental results. Drainage was found to be almost directly proportional to the width of slot and to be greater for inclined and skewed slots. The optimum angle of inclination was found to be approximately 25 degrees.
- (h) "A Study of Flow Into Inclined and Skewed Slots," by A. T. Hjelmfelt, M.S. Thesis, The University of Kansas, Lawrence, June, 1961.

(3743) STUDY OF THE MECHANICS OF DIVIDED FLOW.

- (b) National Science Foundation.
- (d) Theoretical and experimental; basic research.
- (e) In part, a basic study of the mechanism of instability of flow at branches and investigation of the characteristics of the resulting surges. Also an analytical solution for the mean flow into an inclined slot in a plain boundary of a semi-infinite flow is sought.
- (g) Instability has been observed in both two- and three-dimensional flows through symmetrical laterals in ducts and pipes for both equal and unequal division of flow. The temporal variation of discharge may be in phase or 180 degrees out of phase in the two laterals. The variation is closely associated with changes in configuration of the eddy zone in the closed extension of the main pipe or duct. Detailed study of change in the eddy zone in a duct using air is in progress.

(3744) A STUDY OF WAVE EROSION ON UNPROTECTED DIKES.

- (b) Kansas Forestry, Fish and Game Commission.
- (d) Experimental and field investigation; basic research.
- (e) Information to serve as a guide toward a practical solution of wave erosion in waterfowl refuges is sought. The following aspects are being studied: (1) Wave height length and speed are being observed in a pool of uniform shallow depth of about 2 feet, with a fetch of 2.5 miles; and (2) model tests at 1/4 scale are being made of wave action on dikes composed of clay. After the operation of the model has been verified, tests will be run on embankments of various shapes with and without simulated plants and other protective devices.
- (f) Terminated.
- (g) Tests with a 1/4 scale model showed good qualitative reproduction of erosion of clay embankments in the field. Continuous paving and dumped reject bricks (simulated at model scale) were tested with embankment slopes of 2:1 and 3:1. Paved slopes required

- addition of a short riprap blanket at the toe for satisfactory protection. Brick riprap was found to be stable only on the flatter of the two slopes tested. Limited observations of waves in a uniform shallow pool with fetch of 2.5 miles agreed with predictions based on the study made by the Beach Erosion Board (Tech. Memo. 72) of shallow-water waves. This reference shows that the greatest mean wave height occurs for a wind speed below 30 mph with a pool depth of 2 feet.
- (h) "A Study of the Control of Water at Cheyenne Bottoms Waterfowl Refuge," by David W. Appel, Jacob O. Jones and Yun-Sheng Yu, Report to the Kansas Forestry, Fish and Game Commission, September 1961.
- (3745) BASIC CHARACTERISTICS OF AN OVERLAND FLOW.
- (b) Corps of Engineers, Department of the Army.
(d) Theoretical; basic research.
(e) Data from experiments made by the Los Angeles District, Corps of Engineers, on the controlled surface runoff due to steady rainfall on an impervious plane surface are analyzed. The objective is to provide an improved method for estimating overland flow in the drainage of airfields and expressways.
- (g) Assuming quasi-uniform flow, one-dimensional method of analysis was adopted to compute the surface runoff and depth hydrographs due to steady rainfall. Evaporation and infiltration were neglected. Agreement between the computed hydrographs and the measured ones substantiates the validity of the method of analysis. The observed peak in runoff hydrograph immediately after rain stopped can also be estimated from the analysis.
- (4151) SEPARATION OF FLOW AT INTERIOR CORNERS.
- (b) Kimberly-Clark Corporation, Neenah, Wis.
(d) Theoretical and experimental; basic research.
(e) The geometric characteristics of two-dimensional zones of separation at interior corners between two plane boundaries are being investigated. Experiments will span the range from viscous to fully turbulent flows and with various thicknesses of boundary layers ahead of the point of separation.
- (4152) ROUGHNESS OF TURBULENT JETS.
- (b) Laboratory project.
(d) Experimental, basic research and M.S. thesis project.
(e) The surface configuration of jets formed of fully developed turbulent flow discharging from pipes will be studied.
- (4153) INTERACTION OF A FIXED, VERTICAL WALL WITH A TRAIN OF SURFACE WAVES IN SHALLOW WATER.
- (b) Laboratory project.
(d) Theoretical and experimental; basic research for M.S. thesis.
(e) Suppression of surface waves by a fixed, vertical wall in shallow water will be investigated as a possible breakwater. Formal solution of the boundary-value problem based on the assumptions of classical hydrodynamics is sought to determine the reflection and the transmission coefficients. Experiments will be made to compare with theory.
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- LEHIGH UNIVERSITY, Department of Civil Engineering.
- Inquiries concerning the following projects and requests for reprints and technical reports should be addressed to Prof. J. B. Herbich, Chairman, Hydraulics Div., Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania.
- (1602) PRESSURE DISTRIBUTION IN CONDUIT BENDS.
- (b) Laboratory project.
(d) Experimental; undergraduate special problem.
(e) Study of a rectangular bend with a central dividing wall, by means of electrical-analogy has been completed.
- (f) Inactive.
- (1603) BUTTERFLY VALVE STUDY.
- (b) CDC Controls Services, Inc., Hatboro, Pa.
(d) Experimental; applied research.
(f) Completed.
- (2339) BUCKET-TYPE ENERGY DISSIPATOR CHARACTERISTICS.
- (b) Ganett, Fleming, Corddry and Carpenter, Inc., 600 North Second St., Harrisburg, Pa.
(d) Experimental; for general design.
(e) Suspended.
- (2543) STUDY OF CONDUIT EXIT PORTALS.
- (b) Laboratory project.
(d) Experimental; master's of science thesis.
(f) General pressure-distribution study completed.
(g) Tests of square and circular conduit with free-jet, horizontal apron, and three different wall flares, have been completed.
- (3084) STUDY ON IMPROVING DESIGN OF A HOPPER DREDGE PUMP.
- (b) District Engineer, U.S. Army Engineer Dist., Marine Division, Philadelphia, Corps of Engineers.
(d) Applied and Basic Research.
(e) The immediate purpose of the study is to improve design of a hopper dredge centrifugal pump for pumping silt-clay water mixtures. The long-term objective is to determine the effect of Bingham Body-type of fluid on pumping characteristics. The project has been divided into four phases: (1) Model test of existing dredge pump; (2) recommendations for design changes of the dredge pump; (3) model investigation of the modified design of the dredge pump; and (4) analysis of the investigation and final recommendations. Phase 1 involved installation in the hydraulic laboratory of a 1:8 scale model of the dredge pump now used on the U.S. Corps of Engineers dredge ESSAYONS. Water as well as silt-clay-water mixtures (Bingham Body-type of fluid) were pumped and complete characteristics of the pump obtained for capacity of 0 to 1200 gallons per minute, speed of 1150 to 1900 revolutions per minute, and liquid concentrations of 1000 and 1380 grams per liter. Phases 2 and 3 involve modifications in the shape of vane and changes in the exit vane angle of the impeller. Experimental tests indicate considerable improvement in pump efficiency. Phases 1, 2 and 3 completed; 4 - active.
(f) Considerable improvement in pump efficiency has been achieved.
(h) "Effect of Impeller Design Changes on Characteristics of a Model Dredge Pump," by John B. Herbich and H. R. Vallentine. Project Report No. 33, Fritz Engineering Laboratory, Lehigh University, September 1961, Fritz Lab. Report No. 277-PR 33. (Copies available only with sponsor's permission).
"Discussion on Latest Dredging Practice," John B. Herbich, Proc. ASCE, Journal of Waterways and Harbors Division, Paper 2914, 1961 (copies available).
- (3085) STUDY SCALE EFFECT BETWEEN MODEL AND PROTOTYPE SPILLWAYS.
- (b) Laboratory project.
(d) Graduate students' project.
(e) A 1:100 scale two-dimensional model built of Chief Joseph Dam. Prototype crest pressures compared with the data obtained

- (f) on the model.
- (g) Completed.
- (g) Very good correlation obtained between the model and prototype.

with velocities from less than 1 fps to over 30 fps.

(4154) DREDGE PUMP DESIGN.

- (3086) INVESTIGATION OF DESIGN CRITERIA OF SPUR DIKES.
- (b) Modjeski and Masters, Consulting Engineers, Harrisburg, Pa., Lehigh University Inst. of Research.
- (d) Analytical and experimental.
- (e) The project has been divided into four phases: Literature survey; analytical study; experimental study in a fixed-bed model to determine the desired lengths and shapes of spur dikes to provide uniform velocity distribution in the waterway between bridge abutments; (d) experimental study in a movable-bed model to verify findings in part. A spur dike has been defined as a projection extending upstream from the bridge abutments.
- (f) Phases completed; phase active.
- (g) Preliminary investigation indicates that a properly designed spur dike can produce a fairly uniform velocity distribution between the abutments.
- (h) "Control of Bridge Scour by Spur Dikes," by John B. Herbich and H. R. Vallentine, Project Report No. 32, Fritz Engineering Laboratory, Lehigh University, December 1961., Fritz Lab. Report No. 280.32. (In press.)
"Scour Control at Skew Bridge Abutments by Use of Spur Dikes," by M. S. Patel and John B. Herbich, December 1961, Fritz Lab. Report No. 280-M-30. (Copies available.)

- (b) National Bulk Carriers, Inc.
- (d) Experimental.
- (e) The objective of the investigation is to obtain the efficiency and head-capacity curves, to check the effect of the reduced vane exit angle, and to determine the efficiency of a model dredge pump while pumping silt-clay-water mixture of specific gravity equal to 1.17. The experimental tests were carried out on a 1/8 model pump of the National Bulk Carriers Hopper Dredge, S. S. Zulia.
- (f) Completed.
- (h) Report in preparation.

(4155) WAVE RUN-UP ON COMPOSITE BEACHES.

- (d) Graduate students' project. Experimental, applied research for design.
- (e) The main object of the study is to verify existing equations for determining the height of wave run-up and obtain the limits of application of the equation for long beach berms. The study is conducted in a 67 ft.-long, 2 ft.-wide and 2 ft.-deep wave channel equipped with pendulum-type wave generator and efficient absorbers.

(4156) MULTIPLE DREDGE PUMP SYSTEMS.

- (3441) STUDY OF SCALE EFFECT BETWEEN MODEL AND PROTOTYPE 270 DEGREE BENDS FOR FLOW OF SILT-CLAY-WATER MIXTURES.
- (b) Laboratory project.
- (d) M. S. Thesis.
- (e) Four-, six-, and eight-inch diameter 90 degree elbows assembled to form 270 degree bends. Head loss measurements obtained for various flows and concentrations of silt-clay-water mixtures. Prediction equations have been investigated.
- (g) No evidence of appreciable scale effect observed.

- (b) National Bulk Carriers, Inc.
- (d) Experimental and theoretical.
- (e) The study is conducted to determine the effect on total production of dredge pumps with separate discharges and a combined discharge. The investigation is divided into two parts: (a) One pair of pumps is handling a mixture of water and solids, the other is pumping only water. It is required to determine what percentage of its normal output will the dredge pump passing the mixture attain. (b) If one of a pair of dredge pumps, both handling water-solids mixtures, is revolving slower than the other one, how does the total discharge compare to the total if the discharges were not combined?

LOUISIANA STATE UNIVERSITY AND A AND M COLLEGE, Agricultural Engineering Department.

(4157) FURROW IRRIGATION IN SUGAR CANE.

- (b) Research report requirement of master's degree.
- (d) Theoretical.
- (e) Design changes in centrifugal pump impeller for handling mud are suggested on basis of past research and theoretical considerations.
- (f) Completed.
- (3746) ANALYSIS OF FLOW PATTERN IN VOLUTE OF A CENTRIFUGAL PUMP.
- (b) Research report requirement of master's degree.
- (d) Experimental
- (e) High-speed movies of flow taken through a transparent plexiglas volute casing were analyzed. Velocity distribution as well as distribution of the exit angle between the impeller vanes as fluid leaves the impeller were determined.

- (b) Laboratory project
- (c) Mr. James E. Wimberly, Agri. Engr. Dept., Louisiana State University, Baton Rouge, La.
- (d) Experimental; applied research, master's thesis.
- (e) A study of the infiltration characteristics and size of furrow stream for different soil types in the sugar cane area.
- (g) From one year's results, rate of advance equation and infiltration equations for different size furrow streams on three different soil types have been developed.
- (h) "Design of Furrow Irrigation System in Sugar Cane," by James E. Wimberly, Agricultural Engineering Department, Louisiana State Univ., Baton Rouge, Louisiana, unpublished Master's Thesis.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Civil Engineering, Hydrodynamics Laboratory.

- (b) Laboratory project.
- (d) Experimental and theoretical.
- (e) The object of the study is the determination of the pipe flow characteristics of slurries of various concentrations. The slurries do not behave as fluids of constant viscosity so that it is not possible to use conventional methods for prediction of head losses in pipes conveying them. Tests are being conducted in 6-inch, 3-inch, and 2-inch pipelines

Requests for reprints and Technical Reports should be addressed to Dr. Arthur T. Ippen, Professor of Hydraulics, Hydrodynamics Laboratory, Mass. Inst. of Technology, Cambridge 39, Mass.

- (307) MECHANICS OF STRATIFIED FLOW.
- (b) Laboratory project.
 - (c) Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical and experimental; graduate research.
 - (e) A general study of the characteristics of flows in which vertical density gradients are present. Density differences may be due to temperature, chemical composition or solids in suspension. The topic currently under investigation is the forced mixing of a stratified body of water.
 - (g) Circulation and mixing is induced in a two layer stratified reservoir by means of air bubbles introduced from a manifold. An evaluation of the mixing efficiency versus air flow rate is made by comparing the change in potential energy of the reservoir with the energy input at the manifold.
 - (h) "Forced Circulation in Vertically Stratified Fluids by Air Injection," S.M. Thesis, F. T. Gay and Z. Hagedorn, Jr., January 1962.
- (1609) EXPERIMENTAL STUDY OF THE FORMATION OF LITTORAL CURRENTS.
- (b) Beach Erosion Board, U. S. Army Corps of Engineers.
 - (c) Prof. P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Experimental; basic research.
 - (e) Quantitative study of the mechanics of the formation of longshore currents along straight beaches.
 - (g) Current experiments are studying the energy budget in a shoaling wave up to and beyond the breaker in order to define the energy input to a littoral current system.
- (2546) CHARACTERISTICS OF FLOW WITH DILUTE FIBER SUSPENSIONS.
- (b) Technical Association of Pulp and Paper Industries.
 - (c) Prof. A. T. Ippen and Prof. J. W. Daily, Mass. Inst. of Tech; Cambridge 39, Mass.
 - (d) Experimental and analytical; basic research.
 - (e) Basic investigation of hydrodynamics of dilute suspensions.
 - (g) Previous investigations of the hydrodynamics of flowing paper fiber suspensions emphasized the dual role of fiber interlocking and turbulence in the transfer of momentum and shear with such suspensions. The present studies are investigating the role of the suspended medium in modifying the turbulence structure in the absence of particle entanglement and interlocking. Near neutrally buoyant rigid particles are being used. Energy dissipation, velocity profiles and turbulence characteristics are being studied experimentally and analytically.
 - (h) "Concentration Effects of Rigid Particle Suspensions on Turbulent Shear Flow," by T. K. Chu, Civil Engineer Degree Thesis, August 1961.
"Basic Data for Dilute Fiber Suspensions in Uniform Flow with Shear," J. W. Daily and G. Bugliarello, TAPPI Vol. 44 No. 7, July 1961.
"Rheological Models and Laminar Shear Flow of Fiber Suspensions," by G. Bugliarello and J. W. Daily, TAPPI Vol. 44, No. 12, Dec. 1961.
- (2548) TURBULENT DIFFUSION IN STRATIFIED FLUIDS.
- (b) U. S. Public Health Service.
 - (c) Prof. A. T. Ippen, Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical and experimental; basic research (doctoral thesis).
 - (e) An investigation of various turbulent diffusion processes for application to salinity intrusion and waste disposal in partially or well mixed tidal estuaries.
 - (g) The experimental equipment is a 32-foot channel in which turbulence is generated mechanically by means of a stack of expanded aluminum sheets oscillating vertically with amplitudes up to one-half inch and frequencies up to four cycles per second. Concentrations are measured and recorded at various stations by means of probes sensitive to the changes in conductivity. The turbulence level is specified in terms of the measured rate of energy dissipation within the liquid. The effects of gravity convection due to density differences between the diffusant and receiving fluids are separated from turbulent diffusion effects by a series of control tests with zero density difference. Experiments were made to determine the longitudinal distribution of salinity in a uniform estuary with fresh water inflow at one end and a constant ocean salinity maintained at the other end. Salinity distributions are determined for various fresh water inflow rates and turbulence levels in the flume. The one-dimensional salinity distribution is found to be correlated with a stratification parameter expressing the ratio of energy dissipation to the gain in potential energy of the flow in the estuary. Present studies are concerned with the two-dimensional salinity distributions and the relationship of the vertical salinity gradients to the vertical velocity distributions. The reversal of the bottom velocities which is characteristic of estuaries is also shown to be related to the stratification parameter described above.
- (2801) INTERACTION OF WAVES WITH FLOATING BODIES.
- (b) Office of Naval Research, Dept. of the Navy.
 - (c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical and experimental; basic research.
 - (e) Analytical and experimental investigation of interaction of surface waves with basic shapes. Purpose of the study is to develop a feasible prototype floating or moored breakwater structure.
 - (g) Two problems are currently under investigation (1) A study of the effect of a gradual decrease of depth on a train of shallow water surface waves. Reflection and transmission coefficients are being measured for various wave lengths and depths. Results are compared with existing theories. Energy losses due to separation at corners of the sloped bottom are believed to be responsible for differences between theory and experiment. (2) A new type of submerged breakwater consisting of an array of open tubes with their axes parallel to the direction of wave propagation is being tested. Randomness of position and tube length and total force on the array are being investigated in relation to the transmission coefficient of the breakwater.
- (2802) EXPERIMENTAL STUDY OF WAKE MECHANICS.
- (b) Office of Naval Research, David Taylor Model Basin, Dept. of the Navy.
 - (c) Prof. J. W. Daily, Prof. P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Experimental; basic research (doctoral theses).
 - (e) A study of the effect of trailing edge geometry on the characteristics of the wake of a thin flat plate with particular emphasis on transverse plate vibrations. Tests are carried out in a 7-1/2" x 9" water tunnel test section capable of speeds to 40 ft/sec.
 - (g) Measurements of the turbulent structure of

- the early wake behind a stationary thin flat plate have been made in water for various trailing edge geometries and chord lengths. The transfer of energy between plate and fluid is being investigated under conditions in which the fluid motion induces vibrations of the plate.
- (h) "A Total Head Tube for the Broad-Band Measurement of Turbulent Velocity Fluctuations in Water," by P. S. Eagleson and F. E. Perkins, Proceedings Ninth Congress IAHR, Dubrovnik, Yugoslavia, September 1961. "An Investigation of the Early Wake Behind Submerged Flat Plates as Influenced by Trailing Edge Configuration," E. J. Petersen Jr. and G. D. Sylvester, SM and Naval Engineer Thesis, MIT, 1961. "The Structure of the Early Wake of Stationary, Flat Plates, as Influenced by Chord Length and Trailing Edge Geometry," by R. A. Grace, S.M. Thesis, MIT Course I, 1961. "Turbulence in the Early Wake of a Fixed Flat Plate," by P. S. Eagleson, C. I. Hural and F. E. Perkins, Hydrodyn. Lab. Tech. Report No. 46, February 1961.
- (3089) EXPERIMENTAL STUDY OF EROSION IN CURVED CHANNELS.
- (b) Agricultural Research Service, Soil and Water Conservation and Research Div., U. S. Dept. of Agriculture.
- (c) Professors A. T. Ippen and P. A. Drinker, Mass. Inst. of Tech., Cambridge 39, Mass.
- (d) Experimental; basic research (doctoral thesis).
- (e) Investigation of boundary shear stress distribution and magnitude in curved, open channels to determine location and extent of protection required in natural streams.
- (f) Inactive.
- (g) An investigation was conducted on the distribution and magnitudes of boundary shear stresses arising from subcritical flows through curved trapezoidal channels. The test series was designed to determine the effects in the shear patterns of variation in discharge, bend geometry, boundary roughness, and upstream channel alignment. Two flumes of different bend radius and base width were used, each consisting of a single circular curve of 60 degrees central angle, with straight upstream and downstream tangent sections. The greatest part of the test program dealt with flows in smooth channels. For a Froude number range of 0.32 to 0.55, the stream geometries varied as follows: ratio of width to depth $7 < w/y_0 < 12$; ratio of width to centerline radius, $0.29 < w/r_c < 0.80$. In addition two tests were conducted in a rough surfaced channel at stream geometries corresponding to runs in the smooth channel series, and a series of tests was conducted, simulating the flows through U- and S-kind stream patterns. Local boundary shear stresses were measured with round surface Pitot tubes; a modified Pitot tube was developed and calibrated for use on the rough test surface. As the next phase of this study, it is proposed that the effects of bed deformation on the shear pattern, and the propagation of scour areas be investigated, through the introduction of erodible bed material as an experimental variable.
- (h) "Boundary Shear Stresses in Curved Trapezoidal Channels," by P. A. Drinker, Ph.D. Thesis, MIT, September 1961. "Boundary Shear Stresses in Curved Trapezoidal Channels," by A. T. Ippen, P. A. Drinker, O. H. Shemdin, and W. R. Jobin, MIT Hydrodynamics Laboratory Technical Report No. 47, January 1962.
- (3443) COMPUTER STUDY OF POWER PLANT TRANSIENTS.
- (b) Missouri River Division, Corps of Engineers.
- (c) Prof. A. T. Ippen, Prof. F. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
- (d) Theoretical, field measurements; applied research.
- (e) Development of a comprehensive digital computer program for the solution and investigation of the complete transient problem in hydropower installations.
- (g) The problem of load rejection has been programmed for the IBM 709 computer. The problem of load acceptance and surge tank stability is being formulated. Assistance has been furnished the Corps of Engineers in the planning and conduct of a comprehensive field test of Garrison Power Plant. This test involved measurement of all pertinent mechanical, electrical and hydraulic variables under conditions of acceptance, rejection and oscillation of load.
- (3444) EFFECTS OF BASIN GEOMETRY AND VISCOUS DAMPING IN THE AMPLITUDE OF RESONANT OSCILLATIONS IN HARBORS.
- (b) Office of Naval Research, Dept. of the Navy.
- (c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge 39, Mass.
- (d) Theoretical and experimental; basic research (doctoral thesis).
- (e) Investigation of the response of a harbor to waves incident on the harbor opening.
- (g) Initial experimental phase dealt with a circular harbor having a small entrance gap and communicating with the main wave basin by means of an entrance channel. The characteristics of the response of this harbor in the vicinity of the lowest symmetrical resonant mode of oscillation were studied. Present study is concerned with question of modelling a prototype system in the laboratory with respect to the correct periods of resonant oscillations. An experimental program was initiated based on a non-dissipative model system consisting of a small rectangular harbor directly connected to a larger wave basin. The extremely important aspect of coupling was evident in this system which therefore masked the true nature of resonance and showed how difficult it is to adequately describe a prototype system by a simple model. Results indicate that only for very large values of the ratio of wave basin width to harbor width was the model system able to describe the wave periods which excite modes of oscillation in the harbor. Experimental extensions of this are in progress to determine how wave absorbers and filters introduced into the main wave basin effect the resonant characteristics of the small harbor.
- (3445) CHARACTERISTICS OF CROSS WAVES.
- (b) Office of Naval Research.
- (c) Prof. A. T. Ippen, Prof. L. Howard (Math.), Mass. Inst. of Tech., Cambridge 39, Mass.
- (d) Theoretical and experimental; (doctoral thesis).
- (e) An investigation of the stability of two-dimensional standing waves which lead to the development of three-dimensional cross (or edge) waves.
- (f) Inactive.
- (g) The phenomenon of cross waves occurs when a wave generator is operated at high frequencies. Standing cross waves having crests perpendicular to the wave generator may then be observed. A theory of cross waves in a closed tank has been developed. The amplitudes of the various modes of the free surface as functions of the width to length ratio and the amount by which the critical wave amplitude is exceeded by the driving amplitude can be calculated. Experimental measurements have essentially verified the theory.
- (h) "Non-linear Standing Waves in a Rectangular Tank due to Forced Oscillation," by J. D. Lin and L. N. Howard, MIT Hydrodynamics Lab.

- (3446) EFFECT OF PARTICLES ON TURBULENCE AND RESISTANCE IN FREE SURFACE FLOW.
- (b) Laboratory project.
 - (c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical and experimental (doctoral thesis).
 - (e) An investigation of the effect of neutrally buoyant particle suspensions on the resistance coefficient and shape of the velocity profile. Measurements of the intensity and spectrum of the velocity fluctuations in the direction of mean flow are made to study changes in the turbulence structure. The purpose of the first phase is to eliminate the buoyant weight of the particles as a suspension parameter and to develop a phenomenological model to describe the observed effects.
 - (g) The change in shape of the velocity profiles was found to be similar to that obtained in studies with silt and sand suspensions. The turbulence intensity was found to increase with increasing concentration. The results for one particular particle size are correlated against concentration. It was concluded that the buoyant weight of the suspended particles has no primary effect on the flow characteristics.
 - (h) "The Dynamics of Open Channel Flow with Suspensions of Neutrally Buoyant Particles," by A. T. Ippen and C. Elata, Hydrodyn. Lab. Tech. Report No. 45, January 1961.
- (3748) DISPERSION IN POROUS MEDIA.
- (b) U. S. Public Health Service.
 - (c) Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical and experimental; basic research (doctoral thesis).
 - (e) Investigation of the mechanism of dispersion in porous media. Experimental program includes a study of saline water intrusion in coastal aquifers.
 - (g) Longitudinal dispersion in steady and quasi-steady flow has been investigated. Sands and glass beads are being used in the experimental equipment. The hodograph solution for the stationary intruded saline wedge in an idealized confined coastal aquifer has been experimentally verified. Present phase is concerned with the dispersion zone of the wedge when tidal oscillations are introduced at the ocean.
- (3749) RESISTANCE OF ENCLOSED ROTATING DISKS.
- (b) Office of Ordnance Research, U. S. Dept. of the Army.
 - (c) Prof. J. W. Daily, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Experimental and analytical; basic research.
 - (e) Effect of superposed through-flows on boundary layers, secondary motions and surface resistance of enclosed rotating disks.
 - (g) An exploratory study to survey the main features of the flow phenomena using flow visualization techniques as well as quantitative measurements is to be followed by detailed studies in the significant range of variables.
- (3750) WAVE FORCES ON SUBMERGED, MOORED OBJECTS.
- (b) Laboratory project.
 - (c) Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical and experimental; basic research.
 - (e) Investigation of the dynamic behavior and mooring forces on a submerged, buoyant body whose motion is induced by a train of oscillatory surface waves. The objective is to develop a method of predicting amplitudes of motion and mooring forces.
- (g) Two shapes, an ellipsoid of revolution and a sphere, have been tested at various depths of submergence. Objects are moored by a simple cable system so that the motion is that of an inverted pendulum. The controlling parameter is the ratio of the natural frequency of the moored object to the frequency of the surface wave motion. Conditions leading to resonance must be avoided if mooring forces are to be small.
 - (h) "The Dynamics of a Submerged, Moored Sphere in Oscillatory Waves," by Donald R. F. Harleman and W. C. Shapiro, Proc. 7th Conference on Coastal Engineering, The Hague, 1961.
"Dynamic Behavior of Buoyant, Moored Sphere Subject to Wave Forces," by K. S. Chang, S. B. Thesis, M. I. T., June 1961.
- (3751) ANALYSIS OF TIDAL MOTION IN ESTUARIES.
- (b) Laboratory project.
 - (c) Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical; basic research.
 - (e) Formulation of mathematical models for the analysis of the dynamic behavior of tidal estuaries. For a particular estuary in which the tidal amplitudes are known it is desired to predict tidal velocities and rates of energy dissipation. These quantities are necessary for the analysis of salinity intrusion phenomena.
 - (g) Two estuaries have been studied; the Bay of Fundy and the Delaware. In each case computed tidal velocities are in close agreement with observed values. Method does not depend on segmentation of the estuary hence analytical tidal velocity expressions can be determined which are applicable over the entire length. The analysis of energy dissipation rates has been completed.
 - (h) "Tidal Energy Dissipation in the Delaware Estuary," by D. A. Goulis, S. M. Thesis, January 1962.
- (4158) EXPERIMENTAL AND ANALYTICAL STUDY OF THE FORMATION OF LONGSHORE CURRENTS.
- (b) Office of Naval Research, Dept. of the Navy.
 - (c) Prof. P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Experimental; basic research.
 - (e) Quantitative study of the mechanics of the formation of longshore currents.
 - (g) Current experiments are studying the strength of littoral currents generated on a straight, plane impermeable beach as a function of incident wave characteristics, beach roughness and beach slope.
- (4159) INSTRUMENTATION SYSTEM FOR THE ANALYSIS OF RANDOM PROCESSES IN FLUIDS.
- (b) National Science Foundation.
 - (c) Prof. A. T. Ippen, Prof. J. W. Daily, Prof. P. S. Eagleson.
 - (d) Basic research facility.
 - (e) Design and assembly of analog computer for the calculation of correlation and spectrum functions for random variables.
 - (f) A system consisting of recorders, filters, time delays, phase shifters, multipliers, integrators and x-y plotters has been designed and is being purchased. Application is to the analysis of random variables in problems of turbulence, hydro-elastic vibrations and water waves.
- (4160) MOTION OF SUBMERGED BODIES BELOW A FREE SURFACE.
- (b) Office of Naval Research, Dept. of the Navy.
 - (c) Prof. A. T. Ippen and Prof. J. F. Kennedy, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Experimental; basic research.
 - (e) An investigation of the interaction of a free surface and the turbulent wake generated by a moving body. The characteristics

of the free surface behind the moving body and the decay of the wake turbulence are of particular interest.

- (f) Measurements of velocity profiles downstream from a turbulent jet beneath a free surface have been made. These indicate that the free surface has little if any effect on the velocity distribution upstream from the location where the jet intersects the free surface. Apparatus and experimental techniques are now being developed to perform experiments with circular discs towed at various depths below the free surface.
- (4161) MECHANICS OF DUNES AND ANTIDUNES IN ALLUVIAL CHANNELS.
 - (b) Laboratory project.
 - (c) Prof. John F. Kennedy, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Theoretical research.
 - (e) An investigation of the stability of the sand bed-fluid interface of flow over an erodible bed.
 - (g) Linearized potential flow theory and empirical sediment transport relations are being used to investigate the conditions under which the various bed features form, and the characteristics of the bed features. It has been shown that for certain sediment properties and flow conditions, the interface is unstable, and that above a certain critical Froude number antidunes will form while dunes occur at lower Froude numbers.
 - (h) "Stationary Waves and Antidunes in Alluvial Channels," by John F. Kennedy. Report No. KH-R-2, W. M. Keck Laboratory of Hydraulics and Resources, California Institute of Tech., Pasadena, California.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Mechanical Engineering.

- (2807) THE HYDRAULIC ANALOGY APPLIED TO COMPRESSIBLE FLOW IN THE PARTIAL ADMISSION TURBINE.
 - (b) Office of Naval Research and United States Naval Underwater Ordnance Station.
 - (c) Prof. Robert W. Mann, Room 3-459A, Mass. Inst. of Tech., Cambridge 39, Massachusetts.
 - (d) Theoretical and experimental; applied research for master's and doctoral theses.
 - (e) A study of time-varying two-dimensional compressible flow with the goal of design recommendations for partial admission turbine blading, although the results are generally applicable to time-varying two-dimensional geometries.
 - (g) A one-dimensional time-varying analysis of initially supersonic compressible flow through the partial admission turbine has correlated well with analogous water height measurements on a large scale dynamic water table representative of the turbine gas geometry and test conditions. Techniques for photostereo mapping of the two-dimensional water surface have been developed. Two-dimensional data is consistent with previous one-dimensional channel centerline capacitive water height measurement, but illustrate the complexity of the two-dimensional flow. A two-dimensional model has been postulated. Attempts to predict turbine efficiency from the one-dimensional studies have not been fruitful.
 - (h) "Analysis and Experiment on Unsteady Gas Flows Using the Hydraulic Analogy," by M. Suo, S. M. Thesis, Department of Mechanical Engineering, M. I. T., Cambridge, Mass., Jan. 1960.
 "Unsteady Flow Inefficiencies in Partial-Admission Turbines," by R. A. Lucheta, S.B. Thesis, Department of Mechanical Engineering, M. I. T., June 1961.
 "The Hydraulic Analogy Applied to Nonsteady, Two-Dimensional Flow in the Partial-Admission Turbine," by H. K. Heen and R. W. Mann,

Journal of Basic Engineering, Trans. of the ASME, September 1961, pp. 408-422.

- (3092) JET-PIPE CONTROL VALVES.
 - (b) U. S. Air Force and Kearfott, Division of General Precision, Inc.
 - (c) Prof. J. L. Shearer, Prof. S. Y. Lee, Dept. of Mech. Engineering, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Applied research, thesis investigation.
 - (e) An analytical and experimental study of the steady-state and dynamic characteristics of pneumatic, hot-gas and hydraulic jet-pipe control devices. An investigation of the effects of turbulent diffusion of the fluid jets of jet-type devices and an associated investigation of the limitations of using potential flow solutions to predict the characteristics of jet-type devices are included in the overall study. Emphasis is on better understanding the fundamental behavior of jet-type devices.
 - (g) Experimental work conducted to date has produced useful information concerning the steady-state characteristics of conventional hydraulic and pneumatic jet-pipe valves. Optimum design conditions have been established based on certain criteria of merit.
 - (h) "Basic Characteristics of a Pneumatic Jet-Pipe Valve," by K. N. Reid, 1960 Northeast Electronics Research and Engineering Meeting Record, Boston, Mass., November 1960.
 "An Experimental Study of the Design Parameters of Hydraulic Jet-Pipe Valves," by A. C. Curtiss, Thesis (S.M.), Dept. of Mech. Engr., Mass. Inst. of Tech., Cambridge, Mass., June 1961.
 "Steady-State Flow Induced Forces in a Hydraulic Jet-Pipe Valve," by J. C. Tamulis, Thesis (S.M.), Dept. of Mech. Engr., Mass. Inst. of Tech., Cambridge, Mass., Aug. 1961.
- (3447) REACTION-JET SERVOMOTOR.
 - (b) U. S. Air Force.
 - (c) Prof. S.-Y. Lee, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Analytical and experimental.
 - (e) Study the feasibility of using dynamic type fluid motor in servo applications where hot gas is used as a medium.
 - (g) (1) Steady-state torque-speed characteristics, (2) dynamic response, (3) performance of position-control servo systems using the reaction-jet motor, and (4) hot gas applications.
- (3448) FLOW THROUGH CONTROL VALVE ORIFICES.
 - (b) U. S. Air Force, Chandler-Evans Corp., and Hamilton Standard (Div. of United Aircraft).
 - (c) Prof. J. L. Shearer, Mass. Inst. of Tech., Cambridge 39, Mass.
 - (d) Applied research.
 - (e) Experimental investigation of the characteristics of flow through fixed area and variable area orifices with emphasis on resistance to fluid flow and the factors that lead to being able to predict the resistance characteristics over a wide range of Reynolds Numbers.
 - (g) Actual size and large scale models have been studied for hydraulic and pneumatic flows with special emphasis on low Reynold Number flows. Small amounts of rounding of the entrance corners have a very great effect on discharge coefficients at low and intermediate Reynolds Numbers with hydraulic flow. Pneumatic flows have demonstrated bi-stable flow conditions accompanied by hysteresis. A basic investigation is underway of the causes of bistable flows which occur in flapper-nozzle valves. Unsteady flow in poppet valves is also being investigated experimentally.
 - (h) "Discharge Coefficients and Steady-State Flow Forces for Hydraulic Poppet Valves," by J. A. Stone, Trans. ASME, Vol. 82, Series

D, No. 1, March 1960, pp. 144-154.

"Two-Dimensional Transonic Gas Jets," by R. E. Norwood, Sc.D. Thesis, Dept. of Mechanical Engineering, M. I. T., Cambridge, Mass., June 1961.

"Discharge Coefficients for Flow Through Small Orifices," by D. J. Tapparo, S.B. Thesis, Dept. of Mechanical Engineering, M. I. T., June 1961.

(3452) INTERACTIONS AMONG BURNING FUEL DROPLETS AND THEIR EFFECTS ON COMBUSTION STABILITY AND ROUGHNESS.

(b) U. S. Air Force Office of Scientific Research.

(c) Prof. T. Y. Toong, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Theoretical and experimental; basic research for doctoral, master's and bachelor's theses.

(e) Theoretical and experimental investigations of interactions among burning fuel droplets in a steady and oscillating air stream. The main objective is to further an understanding of the general problem of combustion instability.

(g) Theoretical and experimental studies of the interactions between two burning fuel cylinders were carried out. Measured results of burning rate and flame position agree well with the predicted ones.

(h) "A Theoretical Study of Interactions Between Two Parallel Burning Fuel Plates," by T. Y. Toong, Combustion and Flame, vol. 5, No. 3, pp. 221-227, 1961.

"Theoretical and Experimental Study of Interactions Between Two Burning Fuel Cylinders," by T. N. Chen, Sc.D. Thesis, M.E. Dept., M.I.T., May, 1961.

(3456) FLAME PROPAGATION AND STABILIZATION IN BOUNDARY LAYERS.

(b) National Science Foundation.

(c) Prof. T. Y. Toong, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Theoretical and experimental; basic research for doctoral and master's theses.

(e) Basic study of mechanisms of flame propagation and stabilization in a laminar boundary layer adjacent to a heated plate.

(g) Variation of propagation speed of a two-dimensional laminar flame in a heated boundary layer was measured by a particle-track method. Measurements substantiate the burning-velocity profile postulated in the study of mechanism of flame stabilization.

(h) "Determination of the Velocity Field Across a Two-Dimensional Flame by a Particle-Track Method," by Jon R. Kelly, S.M. Thesis, M.E. Dept., M.I.T., May, 1961.

(3457) JET MIXING WITH CHEMICAL REACTION.

(b) Laboratory project.

(c) Prof. T. Y. Toong, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Theoretical and experimental; basic research for doctoral and master's theses.

(e) Theoretical and experimental investigations of the effects of chemical reaction on transport of mass, momentum and energy.

(g) Propagation of kernels ignited at a short distance downstream of the initial contact point between two concentric gas streams of different composition, temperature and velocity were studied by the use of high-speed streak photography. Rapid, successive occurrences of these propagating kernels at different circumferential positions in the mixing zone result in a stable flame.

(h) "An Experimental Study of Ignition and Combustion in a Jet Mixing Zone," by W. M. Rohrer, Jr., S.M. Thesis, M. E. Dept., M.I.T., August 1961.

(3758) FILM BOILING IN FORCED CONVECTION IN HORIZONTAL AND VERTICAL TUBES.

(b) National Science Foundation.

(c) Prof. W. M. Rohsenow, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Experimental and analytical study of heat transfer to film boiling of Freon-12.

(e) A stainless steel tube and an electrically heated glass (Corning Glass Co.) tube of the same size are in parallel and may be run alternately. Heat flux and temperatures are taken in the steel tube, then the flow regime is observed at the same conditions in the glass tube. Effect of liquid subcooling is being investigated.

(g) Results have been obtained for the horizontal tube with the liquid at the saturation temperature. The flow is stratified with no bubbles in the liquid. A vapor film surrounds the liquid. Agreement exists between calculated and measured axial temperature distributions along the top and bottom of the tube.

(3760) PROPULSION THROUGH CHANGES OF BODY SHAPE.

(b) Departmental research.

(c) Prof. A. H. Shapiro, Mechanical Engineering Dept., M.I.T., Cambridge 39, Mass.

(d) Experimental and theoretical research for doctoral thesis.

(e) The object is to understand the propulsion mechanism of a flexible, oscillating plate in a flowing stream.

(g) Experiments underway.

(4162) VALVE STABILITY STUDY.

(b) Hamilton Standard Div., and United Aircraft Corp.

(c) Prof. S. Y. Lee, Mech. Engineering Dept., Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Basic and applied research.

(e) Experimental and theoretical study of stability of control valves of simple configurations; e.g. poppet-type valve and spool-type valve.

(g) Experimental apparatus was developed to measure the dynamic relationship between valve displacement, flow rate, pressure drop and flow forces. It is hoped that deeper insight of the stability of a control valve can be gained by this study.

(h) "Transient Forces on Hydraulic Seating Type Valves," by F. T. Murray, Thesis (S.N.) Dept. of Mech. Engr., Mass. Inst. of Tech., Cambridge, Mass. Sept. 1961.

(4163) A STUDY OF THE STABILITY OF INCOMPRESSIBLE PARALLEL LAMINAR FLOW.

(b) National Science Foundation, Grant No. G 10861.

(c) Asst. Prof. E. F. Kurtz, Jr. Room 3-356 M. I. T. Cambridge, Mass.

(d) A theoretical study in which numerical techniques were used; doctoral thesis.

(e) The study was performed on an IBM 709 Data Processing System located at the Computation Center of the Massachusetts Institute of Technology. The mathematical formulation of the problem is first described, leading to the Orr-Sommerfeld Equation and boundary conditions. In the derivation it is assumed that the flow is incompressible and parallel. The problem is of the eigenvalue type. The solution on a digital computer is obtained by performing a transformation on the mathematical formulation; the differential equations comprising the mathematical formulation are converted into an algebraic model of the differential system. A method is described for reducing the truncation error of the algebraic model so that highly accurate solutions may be obtained at relatively small computing cost. The basic method used to obtain solutions is essentially one of searching by trial for roots of the secular relation. This secular relation is the determinant of the coefficient matrix

- of the algebraic model.
- (f) Completed.
- (g) Results are presented for two laminar flows, the Blasius solution for the laminar boundary layer of an incompressible flow on a flat plate, and the laminar free-convection boundary layer on a vertical heated flat plate. These results consist of eigenvalues of wave velocity, wave number, and Reynolds number, and eigenfunctions for stable, neutrally stable, and unstable disturbances. The results for the Blasius flow agree well with the already available theoretical and experimental results for this flow, confirming that the computer program functions properly. The only results presently available for the free-convection boundary layer, consisting of a single experimental observation, are found to be consistent with the results reported here. Some further results are also presented, showing the physical nature of the disturbances, and some information about the spectrum of the Orr-Sommerfeld Equation.
- (h) "A Study of the Stability of Laminar Parallel Flows," by Edward Fulton Kurtz, Jr. Doctoral Thesis, Massachusetts Inst. of Tech., June 1961.
- (4164) BOILING AND TWO-PHASE FLOW.
- (b) Office of Naval Research, Dept. of the Navy.
- (c) Mr. P. Griffith, Mech. Engineering Dept., Mass. Inst. of Tech., Cambridge 39, Mass.
- (d) Investigation of boiling and two-phase flow.
- (e) To investigate what is the mechanism of bubble agglonevation, the mechanism of bubble departure at various "g" in boiling (i.e. what is the effect of liquid dynamics), and the mechanism of bubble formation in an initially subcooled boiling system.
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- UNIVERSITY OF MASSACHUSETTS, School of Engineering.
- (2561) HYDROLOGY STUDIES IN WESTERN MASSACHUSETTS.
- (b) Cooperative with the U.S. Soil Conservation Service, U.S. Weather Bureau and U.S. Geological Survey. Student assistance has been financed by faculty research grants.
- (c) Prof. George R. Higgins, Engineering Research Institute, Univ. of Mass., Amherst, Mass.
- (d) Experimental-field and laboratory; for design of watershed yield, flood peak reduction, and general information
- (e) Mass curve studies for reservoir and watershed yield have been completed for selected drainage areas in western Massachusetts. An extension of these data combined with an expansion of some field work with regard to runoff characteristics of small drainage areas is planned.
- (f) Temporarily suspended.
- (3766) AN EXPERIMENTAL STUDY OF THE STABILITY OF STANDING (TRAPPED RING) VORTICES IN TWO-DIMENSIONAL INCOMPRESSIBLE FLOW.
- (b) Laboratory project financed by faculty research grant and department funds.
- (c) Dr. Charles E. Carver, Jr., Assoc. Prof. of Fluid Mechanics, Dept. of Civil Eng., Univ. of Mass., Amherst, Mass.
- (d) Experimental; basic research.
- (e) Using a Hele-Shaw table, a vortex is formed in a cusp and the tendency of the vortex to remain in the cusp is studied for various free stream velocities past the cusp as well as for various suction rates applied within the cusp in accordance with a theory of Ringleb.
- (4165) EXPERIMENTAL INVESTIGATION OF TWO-PHASE FLOW.
- (b) Laboratory project.
- (c) Senior student honors project, Dr. E. E. Lindsey supervisor, Associate Dean of Engrg.
- and chairman, Dept. of Chemical Engineering, Univ. of Mass., Amherst, Mass.
- (d) Experimental, basic research.
- (e) Effect of surface tension of pressure drop and slip for two-phase flow; variation in phase ratios along a pipe.
- (4166) AGITATION CHARACTERISTICS IN LIQUID-LIQUID SYSTEMS.
- (b) Laboratory project.
- (c) Dr. E. E. Lindsey, Associate Dean of Engrg., and Chairman, Dept. of Chemical Engineering, Univ. of Mass., Amherst, Mass.
- (d) Experimental; basic research for master's thesis.
- (e) Characteristics of agitation are determined from particle size of dispersions produced; particle sizes measured by light scattering techniques.
- (4167) PRESSURE DROP ACROSS FITTINGS.
- (b) Laboratory project.
- (c) Dr. E. E. Lindsey, Associate Dean of Engrg. and Chairman, Dept. of Chemical Engineering, Univ. of Mass., Amherst, Mass.
- (d) Experimental; senior student honors project, Dr. K. Cashin, supervisor.
- (e) Pressure drop is measured for a number of different pipe fittings placed in series and at different spacings; effect of approach conditions investigated.
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- MICHIGAN STATE UNIVERSITY, Department of Civil Engrg.
- (2125) SMALL AGRICULTURAL WATERSHED HYDROLOGY.
- (b) Michigan Agricultural Experiment Station.
- (c) Prof. E. H. Kidder, Agricultural Engrg. Dept. Michigan State University, East Lansing, Mich.
- (d) Field investigation; for design.
- (e) Samples of runoff water are collected at periodic intervals and more frequent intervals during flood flow to determine the concentration of sediment being transported. Runoff gaging stations serviced by USGS. Dense network of 22 recording raingages for 25 square mile area in two watersheds.
- (g) Sediment content of runoff is low.
- (2126) SURFACE AND SUBSURFACE DRAINAGE.
- (b) Michigan Agricultural Experiment Station.
- (c) Prof. E. H. Kidder, Agricultural Engineering Dept., Mich. State Univ., East Lansing, Mich.
- (d) Experimental; field investigation, applied research.
- (e) To study the effect of bedding, bedding and moling, bedding and tile, and tile drainage on crop yields in a submarginal farming area. Crop yields in a grain-grain hay-hay rotation are measured in increments away from the drainage feature.
- (g) Two rod tile lateral spacing has given the highest crop yields. A 60-foot tile spacing ranks second.
- (2127) AN INVESTIGATION OF THE STABILITY AND DURABILITY OF SUBSURFACE DRAINS PLACED IN MUCK.
- (b) Michigan Agricultural Experiment Station.
- (c) Prof. E. H. Kidder, Agricultural Engineering Dept., Mich. State Univ., East Lansing, Mich.
- (d) Experimental; field investigation; applied research.
- (e) Four lateral underdrains were placed in muck (ph 6.5). Concrete and clay tile in one- and two-foot lengths, perforated steel pipe in eight-foot lengths, and perforated fiber pipe in six-foot lengths were installed in 1952. Elevations of the ground surface and the underdrains are taken annually. Quality of the material is checked at four-year intervals.

- (g) The soil surface subsided 0.8 to 0.9 feet the first year, with little subsidence since. The underdrains settled 0.3 feet the first year, negligible since. Concrete drain tile from three manufacturers deteriorated by acid action. Considerable rusting was noted on galvanized steel. Hay blinding material was in excellent condition.
- (3102) WATER REQUIREMENTS OF PLANTS.
- (b) Michigan Agricultural Experiment Station.
(c) Prof. E. H. Kidder, Agricultural Engineering Dept., Mich. State Univ., East Lansing, Mich.
(d) Experimental, field investigation; applied research.
(e) Four areas are protected against natural rainfall during the cropping season. Precision irrigation is practiced to maintain four levels of available water in the soil. Meteorological, evapotranspiration and evaporation data are also collected.
(g) The highest level of available water (range between 70 and 100% in the surface foot) gives the highest yield of potatoes. Consumptive use peak rate of 0.18 inches per day.
- (3104) SPRINKLER IRRIGATION FOR FROST PROTECTION OF PLANTS.
- (b) Michigan Agricultural Experiment Station.
(c) Prof. E. H. Kidder, Agricultural Engineering Dept., Mich. State Univ., East Lansing, Mich.
(d) Experimental, laboratory and field investigation; applied research.
(e) To determine the application rates and repeat frequency of water application to give effective protection to plants against frost damage.
(g) Application rates of 0.1 inch per hour repeat frequency of 12 to 20 seconds have protected truck crops against minimum temperature of 19 degrees F.
- (3105) SHEAR AND PRESSURE DISTRIBUTION ON DUNE-SHAPED BOUNDARIES.
- (b) National Science Foundation.
(c) Dr. E. M. Laursen, Dept. of Civil Engrg., Mich. State Univ., East Lansing, Mich.
(d) Experimental; basic research.
(e) Since the bed of an alluvial stream commonly consists of dunes and ripples, the distribution of shear and pressure over these roughness elements is of interest in regard to both sediment transportation and resistance to flow. A 44-foot Lucite conduit with schematic triangular dunes and air as the fluid is being used in the experimental investigation.
- (3767) SYNTHESIS OF SEDIMENT-TRANSPORTING CHARACTERISTICS OF STREAMS.
- (b) Laboratory project.
(c) Dr. E. M. Laursen, Dept. of Civil Engineering, Mich. State Univ., East Lansing, Mich.
(d) Analytical; applied research, for M. S. thesis.
(e) The assumption is made in this investigation that the variability of sediment load for a given discharge of a natural stream can be explained by a temporary change in the bed material of the stream due to the addition of fine material during surface runoff. Field data of the U.S.G.S. at several locations is being used to test this hypothesis.
(f) Completed.
(g) Variability of bed material, of water temperature, and of stream characteristics are more than sufficient to explain the variability of the sediment load of the natural streams investigated.
(h) "Synthesis of Sediment Transporting Characteristics of Alluvial Channels," by G. A. Zernail, M. S. Thesis, Mich. State University.
- (3768) SPILLWAY PROFILES FOR DESIGNATED UNDER-PRESSURE.
- (b) Laboratory project.
(c) Dr. E. M. Laursen, Dept. of Civil Engineering Mich. State Univ., East Lansing, Mich.
(d) Analytical; applied research, for Ph.D. Thesis.
(e) The idea of a constant underpressure spillway shape has been tested and found promising. An analytical method of determining the required profile is being sought.
(g) An experimental comparison of a standard and an underpressure spillway indicated that the underpressure profile has merit.
(h) "Design of Spillways for Underpressure," by J. R. Adams, M. S. Thesis, Michigan State University.
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- UNIVERSITY OF MICHIGAN, Department of Civil Engrg.
- (3769) WAVE REFRACTION IN A TRAPEZOIDAL CHANNEL.
- (b) Laboratory project.
(c) Prof. E. F. Brater, Prof. of Hydraulic Engineering, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Investigation of the refraction of waves which enter a trapezoidal channel from deeper water.
(f) Experimental work completed.
(g) Analysis of data is near completion.
- (3770) ROLL WAVES.
- (b) Laboratory project.
(c) Prof. E. F. Brater, Prof. of Hydraulic Engrg., Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Investigation of the characteristics of a wave generated by a disturbance at the entrance to a channel.
- (3771) WATER HAMMER.
- (b) Laboratory project.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Investigation of friction effects on water hammer attenuation, by introducing friction losses in the differential equations, solving them by different methods using a high speed computer. Experimental study of water hammer under conditions of high friction.
(f) Project completed.
(g) A theoretical analysis of water hammer with fluid friction is developed from the basic partial differential equations. These equations are solved directly by the method of characteristics, with the aid of a digital computer. Examples have been worked and are presented, together with their experimental verification.
(h) "A Study of Waterhammer Including Effect of Hydraulic Losses," Industry Program, Univ. of Mich. 1961.
- (4168) UNSTEADY GRAVITY FLOW OF LIQUIDS THROUGH POROUS MEDIA.
- (b) Laboratory project.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Study of flow through porous media, for cases of free surface flow with upstream

free surface varying with time.

UNIVERSITY OF MINNESOTA, Agricultural Experiment Station.

(1929) DRAIN TILE JUNCTION LOSSES.

Cooperative with St. Anthony Falls Hydraulic Laboratory. See page 61.

(2350) DRAINAGE OF AGRICULTURAL LAND BY PUMPING.

- (b) Laboratory project.
- (c) Prof. Curtis L. Larson, Dept. of Agricultural Engineering, Univ. of Minnesota, St. Paul 1, Minnesota.
- (d) Theoretical and field investigations; applied research.
- (e) The project has three phases: (1) The development of basic relations for planning pump drainage systems, (2) the study of rates of drainage, and (3) the study of factors affecting the efficiency.
- (g) Tests of a propeller pump with various rates of cycling and with various suction conditions have been completed and a report is being prepared.
- (h) "Factor in Drainage Pumping Efficiency," by C. L. Larson and D. M. Manbeck, The Journal of the American Society of Agricultural Engineers, 42(6): 296-7, 305, June 1961.

(2576) CONSTRUCTION, DEVELOPMENT, AND PUMPING OF SHALLOW WELLS FOR IRRIGATION.

- (b) Field project.
- (c) Prof. Evan R. Allred, Dept. of Agricultural Engineering, Univ. of Minn., St. Paul 1, Minn.
- (d) Field investigation; applied research and development.
- (e) The objectives of the project are: (1) To study and develop inexpensive methods for construction of shallow irrigation wells, (2) determine hydraulic permeability and characteristics of various aquifers, and (3) to survey and determine extent and availability of shallow ground water sources for irrigation in Minnesota.

(3470) HYDRAULIC PERFORMANCE OF IRRIGATION BOOM-SPRINKLERS.

- (b) Field and laboratory project.
- (c) Prof. Evan R. Allred, Dept. of Agricultural Engineering, Univ. of Minn., St. Paul 1, Minn.
- (d) Primarily field investigation; applied research.
- (e) The objective of the project is to determine the effect of wind velocity, nozzle arrangement, rotation speed and operating pressure on the distribution from irrigation boom-sprinklers.

MISSOURI SCHOOL OF MINES AND METALLURGY, Dept. of Civil Engineering.

(319) WEIR STUDIES.

- (b) Laboratory project.
- (c) Prof. E. W. Carlton, Civil Engrg. Dept., Missouri School of Mines and Metallurgy, Rolla, Missouri.
- (d) Experimental; basic research for master's thesis.
- (e) Tests on rectangular weirs were made to determine effect of velocity of approach on the relation between crest depth and critical depth of an imaginary open channel having same dimensions as the weir opening.
- (g) Study produced a simple, accurate and quick solution for plotting of M function. Relationship between the M function, and the

critical depth is logarithmic. This greatly simplifies determination of critical flow where the critical depth is known or vice versa. A relationship exists between M function of channels of same shape but different dimensions. The velocity of approach does not affect the relationship between physical depth and crest depth.

(2578) CORRELATION OF WEIR CREST DEPTH AND WEIR FLOW CHARACTERISTICS.

- (b) Laboratory project.
- (c) Prof. Clifford D. Muir, Civil Engineering Dept., Missouri School of Mines and Metallurgy, Rolla, Missouri.
- (d) Experimental.
- (e) Tests on several cipoletti weirs were made in order to determine the effect of weir thickness, H/P ratio, and Froude's Number on the ratio of crest depths to the critical depth of an imaginary open channel having the same dimensions as the weir flow section.
- (f) Suspended.
- (g) This study indicated a definite relationship between the crest depth to critical depth ratio and the Froude Number of the imaginary channel. However, the ratio tended to become constant at either high or low Froude Numbers. The H/P ratio had no noticeable effect on this relationship. A continuation of this study indicates probable superiority of crest depth flow relationships, when weirs having a narrow width with respect to head are being used.

(3772) CULVERT INLETS WITH SKIMMING HOODS.

- (b) Laboratory project.
- (c) Prof. C. D. Muir, Assoc. Prof. of Civil Engineering, Missouri School of Mines, Rolla, Missouri.
- (d) Experimental; basic research for master's thesis.
- (e) Model tests are being conducted on culvert inlets with several types of skimming hoods in order to study their efficiency and possible application to sanitary lagoons.
- (f) Suspended.
- (g) Tests indicated that a box-type hood coupled with a reentrant pipe can be adopted to use with small sanitary lagoons.
- (h) "Hood Inlet, Possible use as an Overflow for a Sanitary Lagoon," Richard I. Boe, Master's Thesis, Missouri School of Mines, 1961. (Available on loan).

(3773) PIPE FRICTION WHEN PUMPING FLUID-SOLID MIXTURES.

- (b) Laboratory project.
- (c) Prof. C. D. Muir, Assoc. Prof. of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
- (d) Experimental; basic research for master's thesis.
- (e) Tests were run pumping various mixtures of water and sand through a 3/4 inch pipe in order to study friction factors when solid transport was part of the flow.
- (f) Suspended.
- (g) Tests indicate a relationship exists between friction factor and solids percentage at all flow conditions. Also there appears to be a critical percentage of sand above which the mixture can no longer be pumped as a slurry.
- (h) "Effects of Solids on Friction Factor in a Sand-Water Mixture," by Frank J. Capek, Master's Thesis, Missouri School of Mines, 1961. (Available on loan).

(3774) CULVERT INLET STUDIES.

- (b) Laboratory project.
- (c) Prof. C. D. Muir, Assoc. Prof. of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
- (d) Experimental; basic research for master's thesis.

- (e) Model tests for a culvert were conducted to study culvert efficiency at partial flow and the formation of critical depth at the inlet. These tests were limited to a circular inlet.
- (f) Suspended.
- (g) Results of study indicated a need for culvert entrance configuration study.

(3775) VERTICAL WATER JET IMPACTING UPON A STILLING BASIN.

- (b) Laboratory project.
- (c) Prof. V. A. C. Gevecker, Civil Engineering Department, Missouri School of Mines and Metallurgy, Rolla, Missouri.
- (d) Experimental; basic research for master's thesis.
- (e) Tests being conducted on the terminal effect of a 3/8 inch water jet on a cylindrical stilling basin to determine side and bottom pressures, velocities and energy dissipated.

(4169) INVESTIGATION OF VERTICAL INTERNAL SPILLWAYS.

- (b) Laboratory project.
- (c) Prof. C. D. Muir, Assoc. Prof. of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
- (d) Experimental; basic research for master's thesis.
- (e) A scale model rockfill dam containing a vertical internal spillway was studied to determine factors affecting stage-discharge relationships.
- (g) A correlation was found to exist between discharge through the dam and height of spillway, rock size, and head.
- (h) "Investigation of Vertical Internal Spillways," by Paul R. Munger, Master's Thesis, Missouri School of Mines, 1961. (Available on loan).

MONTANA STATE COLLEGE, Agricultural Experiment Station.

(3109) IMPROVING THE EFFICIENCY OF IRRIGATION APPLICATION BY BORDER IRRIGATION.

- (b) Agricultural Engineering Department, Agricultural Experiment Station; U. S. Bureau of Reclamation cooperating.
- (c) Prof. Charles C. Bowman, Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana.
- (d) Experimental and basic research.
- (e) Laboratory studies of basic principles which govern the flow of water at a shallow depth over rough ground under various densities of crop growth. Supplemented by field experiments and tests.
- (g) Annual reports of progress have been made to the Director and to the Bureau of Reclamation.
- (h) "More Efficient Application of Irrigation Water," by Charles C. Bowman. (Recently submitted for publication in the Journal of American Society of Agricultural Engineers).

(3472) INTERCEPTION AND ITS EFFECT ON PRECIPITATION DISPOSAL.

- (b) Agricultural Engineering Department, Mont. Agricultural Experiment Station.
- (c) Mr. Charles C. Bowman, Montana State College, Bozeman, Montana.
- (d) Basic research in field of hydrology.
- (e) Development of instrumentation to measure transpiration and evaporation under coniferous canopies on mountain watersheds.
- (g) Positive results have been achieved in instrumentation.

UNIVERSITY OF NEBRASKA, Hydrodynamics Laboratory,

Dept. of Engineering Mechanics.

(3776) VORTEX FORMATION AND DRAG IN UNSTEADY FLOW PAST BLUFF BODIES.

- (b) National Science Foundation.
- (c) Prof. T. Sarpkaya, Dept. of Engineering Mechanics, Bancroft Hall 219, University of Nebraska, Lincoln 8, Nebraska.
- (d) Experimental and theoretical study of drag and inertia in unsteady flow. Basic research for master's and Ph.D. thesis.
- (e) Primary objects of the research are: To determine the growth and motion of vortices behind two dimensional bluff bodies subjected to unsteady flow; to determine the basic characteristics of the corresponding resistance; and to correlate a particular vortex configuration with the instantaneous resistance.
- (g) The forces predicted on the basis of the moving and growing singularities are comparable in magnitude to forces which are observed.

(3778) REFLECTION, TRANSMISSION, AND ATTENUATION OF PULSE WAVES IN BIFURCATING ELASTIC CONDUITS.

- (b) Cardiovascular Research Center, Medical School, University of Nebraska. Laboratory project.
- (c) Mr. Randolph M. Clark, Bancroft Hall 219, University of Nebraska, Lincoln 8, Nebr.
- (d) Theoretical and experimental; applied research for master's thesis.
- (e) The purpose of the project: To determine the effect of the dynamic modulus of elasticity and Poisson's ratio of the conduit wall on the characteristics of elastic wave propagation; the rate of damping of the elastic wave pressure; the transmission and reflection coefficients; and to correlate the results obtained from this research with the propagation of pulse waves in arterial system.
- (g) Dynamic elastic characteristics of the tube wall are of primary importance in studying the propagation of pulse waves in highly deformable systems.
- (h) "Propagation of Surges in Highly Deformable Systems," by T. Sarpkaya, Fluid and Solid Mechanics Vol. 1, Plenum Press, 1961.

(3780) MECHANISM OF TURBULENCE GENERATION IN PULSATING VISCOUS FLOW.

- (b) Laboratory project.
- (c) Prof. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln 8, Nebraska.
- (d) Experimental and theoretical basic research; for master's thesis.
- (e) To understand the mechanism of generation of turbulence in pulsating viscous flow superposed on the steady and initially laminar flow.
- (g) When the amplitude ratio of the pulsating pressure gradient to steady one is not large, the maximum dissipation occurs at the wall. However, with the increase of the amplitude ratio the position of the maximum dissipation moves into the flowing fluid and its distance varies with time.

(3782) INDUCED MASS OF CONFINED FLUIDS.

- (b) Laboratory project.
- (c) Prof. T. Sarpkaya, Bancroft Hall 219, University of Nebraska, Lincoln 8, Nebr.
- (d) Theoretical basic research; for master's thesis.
- (e) When a confined fluid is suddenly accelerated through an opening, initial acceleration is determined by the induced mass of the fluid system. This mass has been determined by the induced mass of the fluid system. This mass has been determined through the application of the Schwartz-Christoffel transformation and electrical

- (f) analogy.
- (g) Completed.
- (h) The effect of the induced mass is most pronounced particularly for short conduits. If it is ignored initial accelerations turn out to be unrealistically large.
- (h) "Unsteady Flow of Fluids in Closed Systems," T. Sarpkaya, submitted to ASCE, EM Division for publication, October 1961.

(4170) VIRTUAL MASS OF PARTLY SUBMERGED BODIES.

- (b) Laboratory project.
- (c) Prof. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln 8, Nebr.
- (d) Experimental and theoretical basic research.
- (e) Study of the added mass of various objects partly submerged in a liquid.

(4171) TRANSITION CURVES OF CONSTANT PRESSURE.

- (b) Laboratory investigation.
- (c) Mr. Clarence J. Garrison, Hydrodynamics Lab., Bancroft Hall, University of Nebraska, Lincoln 8, Nebraska.
- (d) Basic theoretical research.
- (e) The purpose of the project: To determine the form of the curved boundaries of transition curves along which the pressure is an arbitrarily assigned constant through the use of the Helmholtz-Kirchhoff theory for free streamlines.
- (g) Several transition curves of constant pressure have been evaluated and used to determine the induced mass of reservoir-conduit systems, (see 3782).

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY.

Inquiries concerning the following projects should be addressed to Mr. C. H. Hancock, Hydraulic Lab., Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia.

(123) HYDRAULIC TURBINE TESTS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Scale model turbines, using either Francis or propeller type runners, are tested for power and efficiency at various speeds.

(124) METER CALIBRATION TESTS.

- (b) Laboratory project.
- (d) Experimental.
- (e) To establish calibration curve for determining correction for various rates of flow. Meters are tested at various rates of flow by weighing tank method. Time is recorded electronically by decade counters.

(836) VANE MOMENT TESTS ON ADJUSTABLE BLADE RUNNERS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Tests are to determine vane moments at various gate openings, blade positions and speeds. The turbine load is applied by an electric dynamometer and speed is measured with a decade counter. The blades are held in position by an amplidyne control system on a spider rod through the shaft. The blade moments are obtained from a proving ring by means of electric strain gages.

(901) SHIP MODEL RESISTANCE TESTS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Scale ship models are towed to determine effective horsepower, bare hull, required by the ship. Because of their small size, several models may be towed in a short period of time thus allowing much preliminary work to be done on the choice of lines.

Final lines are checked by David Taylor Model Basin. To eliminate a large portion of this preliminary testing, a schedule of systematic models was arranged in which the beam-draft ratio, the displacement-length ratio, and the prismatic coefficient are varied over a wide range. Towing this set of models is continuing and when completed will provide design data for a standard offset series covering a wide range.

(1132) HYDRAULIC PUMP TESTS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Scale model pumps, centrifugal and propeller types, are tested at constant speeds for head developed, power consumption, and efficiency at various rates of discharge. Cavitation tests are sometimes conducted by lowering the suction head to a point where the developed head and efficiency break down. Blade moments are measured by installing electric resistance strain gages on the pump blade stem. Shear strains are transmitted from the pump via a slip ring.

(1133) CAVITATION TESTS OF HYDRAULIC TURBINE MODELS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Scale model turbines are tested on cavitation stand to determine sigma at which cavitation starts. By the use of a plexiglas throat ring and a Strobolux light synchronized with the shaft rotation, visual observations are made to determine the location on the blade where cavitation starts. Tests were run to determine runaway speeds at low sigma values.

(2582) AIR TESTS ON HYDRAULIC TURBINE MODEL.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Plexiglas hydraulic turbine model is tested with air. Smoke and tufts are used in the flow visualization studies. Velocity and pressure distribution studies are made using a sensitive differential manometer. The gate moments obtained from the pressure distribution will be checked with a strain gage dynamometer.
- (f) Suspended.

(3111) PUMP-TURBINE TESTS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Pump-turbine models are tested either as a pump or turbine on this test stand. Cavitation as well as performance tests on pump, turbine or pump-turbine models can be made on this facility. Provision has been made to perform vane moment tests on adjustable blade turbine runners at the same time as performance tests.

(3783) AIR CONTENT CAVITATION OF TURBINES.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Study of cavitation of hydraulic turbines as affected by the air quantity contained in the tunnel.

(3784) PITOT TUBE CALIBRATION.

- (b) Laboratory project.
- (d) Experimental.
- (e) Calibration of a small 3-hole cylindrical search tube to determine accuracy as affected by blockage, pipe wall, angularity, discharge and fabrication.
- (g) Results within 1/2 percent can be attained for velocity. The angle can be determined to within 0.1 degree.

(3785) VELOCITY PROFILE IN TURBINE MODEL.

- (b) Laboratory project.
- (d) Experimental; applied research and development.
- (e) Determination of velocity distribution through a two-dimensional turbine affected by entrance angle, hub configuration, and distributor height.

(3786) FLOW STRAIGHTENERS.

- (b) Laboratory project.
- (d) Experimental and theoretical; applied research.
- (e) Testing of different shapes for the straightening of flow in short pipes.

(3787) ADDED MASS OF TURBINES.

- (b) Laboratory project.
- (d) Experimental and theoretical; applied research.
- (e) Determination of the effects of added mass of a propeller on the efficiency and blade moment step-up formulas from model to prototype.

NEW YORK UNIVERSITY, Department of Chemical Engrg.

(2583) EFFECT OF PARTICLE CONCENTRATION ON PRESSURE DROP AND SEDIMENTATION VELOCITY IN DILUTE BEDS OF PARTICLES.

- (b) Grants from Texas Company and American Chemical Society; laboratory project.
- (c) Professor J. Happel, Dept. of Chemical Engineering, New York University, Univ. Heights, New York, 53, New York.
- (d) Theoretical; basic research for doctoral thesis.
- (e) The slow translational motion of dilute beds of particles settling through viscous fluids subjected to the influence of cylindrical boundaries is being studied. This will ultimately enable a theoretical prediction of the effect of particle concentration on pressure drop and sedimentation velocity in beds of particles.

(3474) HEAT TRANSFER AND CHEMICAL REACTION RELATIVE TO BEDS OF SPHERICAL PARTICLES.

- (b) Laboratory project.
- (c) Prof. J. Happel, Dept. of Chemical Engineering, New York University, University Heights, New York, 53, New York.
- (d) Theoretical; basic research for doctoral thesis.
- (e) Analytical solution is developed by assuming a model where fluid is flowing between two concentric spheres which are maintained at different temperatures. The partial differential equations applicable are solved by assuming power series solutions in temperature and in spherical co-ordinate. The results will be compared to existing data on heat and mass transfer in packed and fluidized beds.

(3788) BOUNDARY LAYER MASS TRANSFER WITH HETEROGENEOUS CATALYSIS.

- (b) Grants from American Chemical Society and National Science Foundation; Laboratory project.
- (c) Prof. J. Happel, Dept. of Chemical Engrg., New York University, University Heights, New York 53, New York.
- (d) Theoretical; basic research for doctoral thesis.
- (e) This work includes a study of the rate of gas-solid catalytic reactions in multiparticle systems. Using boundary layer theory in conjunction with a model consisting of a solid sphere inside a free-surface spherical cell, the relationship between

rates of diffusion and rates of surface-catalyzed reactions is developed.

- (g) Theoretical results for chemically dilute systems correlate existing mass transfer data reasonably well. It was found that molar convective transport to or from the surface affects the mass transfer rate and may give appreciably different results than those obtained from film theory or the dilute solution equation. A simple criterion is set up to determine when the dilute solution correlations can be used.

(4172) PRESSURE LOSS IN ORIFICE BAFFLED HEAT EXCHANGERS.

- (b) Laboratory project.
- (c) Prof. Robert O. Parker, Department of Chemical Engineering, New York University, New York 53, New York.
- (d) Experimental; basic research for master's degree.
- (e) Project to determine pressure loss on the shell side of orifice baffled, shell and tube heat exchangers. Three exchangers are used in this experiment. All are exactly alike except for the fact that one has no clearance between the tube and tube hole, one has no clearance between the baffle and the ID of shell, and one has clearances at both points. This study will determine the effect of each flow stream, and the effect of their interaction.

(4173) DETERMINATION OF THE STOKES'S DRAG ON A PARTICLE FALLING IN AXISYMMETRIC FLOW IN A BOUNDED MEDIUM.

- (b) Laboratory project.
- (c) Prof. H. Brenner, Dept. of Chemical Engrg., New York University, New York 53, New York.
- (d) Theoretical; basic research for master's degree.
- (e) The purpose is to determine the effect of the walls of a container on the Stokes's drag of a particle falling in axisymmetric flow in a fluid. The shape of the container is beaker-like.

(4174) THE PRESSURE DIFFERENTIAL DUE TO A PARTICLE SETTLING IN A VISCOUS FLUID.

- (b) Laboratory project.
- (c) Prof. H. Brenner, Dept. of Chemical Engrg., New York University, New York 53, New York.
- (d) Experimental; basic research for master's degree.
- (e) Experiments are designed to verify certain theoretical relationships pertaining to the dynamics of a particle in a viscous fluid. Pressure differentials due to spheres settling at low Reynolds numbers in a cylinder containing a viscous fluid will be measured and correlated with particle drag.

NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

(2356) SHIP MOTIONS PROJECT.

- (b) David Taylor Model Basin, Dept. of the Navy
- (c) Prof. Willard J. Pierson Jr., Prof. of Meteorology, New York Univ., University Heights, New York 53, New York.
- (d) Theoretical and experimental; basic and applied research.
- (e) Studies of the theory of a stationary Gaussian process as applied to the motions of ships in waves; experimental and theoretical determination of co-spectra and quadrature spectra.
- (g) Theoretical studies of cross spectra and bi-quadratic spectra, and theoretical paper on wave theory and ship motion theory.
- (h) "Estimation of the Transfer Function of a Quadratic System," by L. J. Tick, 1961. (To appear in Technometrics.)

(2357) WAVE PROJECT.

- (b) Bureau of Ships, Dept. of the Navy.
- (c) Prof. Willard J. Pierson, Jr., Prof. of Meteorology, New York Univ., University Heights, New York 53, New York.
- (d) Theoretical and experimental; and basic and applied research.
- (e) Attempts to solve various probabilistic problems in connection with stationary Gaussian noise.
- (g) Work is continuing on the joint density of amplitude and half period and on improved zero and ordinate crossing techniques.
- (h) "A Study of Ocean Wave Amplitudes in Terms of the Theory of Runs and a Markov Chain Process," by M. D. Sawhney, (Unpublished manuscript to appear as a technical report.)

(3120) OFFICE OF NAVAL RESEARCH ATMOSPHERE INTER-ACTION AND WAVE PROJECT.

- (b) Geophysics Branch, Office of Naval Research, Department of the Navy.
- (c) Prof. Gerhard Neumann, Prof. of Oceanography and Prof. Willard J. Pierson, Prof. of Meteorology, New York University, New York 53, New York.
- (d) Experimental and theoretical; basic and applied research.
- (e) Study of wave generation and propagation in deep water; nonlinear properties of capillary and gravity waves in both Eulerian and Lagrangian form. Observations of temperature, humidity, and wind over the sea surface. Albedo measurements. Wind stress over the water surface. The prediction of large scale oceanic circulations. Theoretical and observational studies of turbulence in water.
- (g) Models of random seas in Lagrangian form have been developed that look promising. Field work will be augmented by the acquisition of a T-boat and additional scientific equipment for it.
- (h) "The Average Horizontal Wind Driven Mass Transport of the Atlantic for February as Obtained by Numerical Methods," by D. M. Garner, G. Neumann, and W. J. Pierson, Jr., (In press, 1961.)
"On the Effect of Bottom Topography on Ocean Currents," by G. Neumann, Deutsche Hydr. Ztschr., vol. 13, Heft 3, pp. 132-141, 1960.
"On the Albedo of the Sea Surface," by G. Neumann and R. Hollman, Symposium on Radiant Energy in the Sea, Helsinki, Aug. 4-5, 1961. Edited by N. C. Jerlov, Printed by the Nat. Geogr. Inst., Paris, 1961.
"Power Spectrum Analyses of Turbulent Surface Winds Over Water Under Inversion Conditions," by J. Pandolfo, Tech. Report, prepared for ONR under contract Nonr 285(03) July 1961.
"Models of Random Seas Based on the Lagrangian Equations of Motion," by W. J. Pierson, Tech. Report, prepared for ONR under contract Nonr 285(03), April 1961.
"Known and Unknown Properties of the Frequency Spectrum of a Wind Generated Sea," by W. J. Pierson and G. Neumann, Paper prepared for the Wave Spectrum Conference at Easton, Maryland, May 1-4, 1961.
"Non-Linear Probability Models of Ocean Waves," by L. J. Tick, NAS NRC Conference on Ocean Wave Spectra, Easton, Maryland, May 1-4, 1961. (Also supported under (2356) and (2357).)
"A Non-Linear Random Model of Gravity Waves I: Finite Depth Case," by L. J. Tick, (Unpublished manuscript.)
"A Non-Linear Random Model of Gravity Waves III: Construction of a Realization," by L. J. Tick and G. Radin, 1960 (Unpublished manuscript.)

ENGINEERING OF THE UNIVERSITY OF NORTH CAROLINA,
Department of Engineering Research.

(1636) RAINFALL, INTENSITY, DURATION, FREQUENCY, CURVES FOR NORTH CAROLINA.

- (b) Laboratory project.
- (c) Prof. Charles Smallwood, Dept. of Civil Engineering, North Carolina State College, Raleigh, North Carolina.
- (d) The collection and analysis of data pertaining to intensity, duration and frequency of rainfall in North Carolina.
- (e) Project is concerned at the present time with the collection of pertinent rainfall data from a large number of stations throughout North Carolina.
- (g) Since work is continuing, no conclusive results are available at this time.

NORTH DAKOTA STATE UNIVERSITY, Agricultural Engrg. Dept.

(3121) PREFABRICATED DITCH LININGS.

- (b) Laboratory project.
- (c) Mr. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
- (d) Experimental; applied research.
- (e) The work involves field testing of 4 to 10 mil polyethylene linings by measuring seepage losses in irrigation ditches where these linings have been installed. Some of the linings are buried and some are on the surface of the ditch.
- (g) Six and ten mil buried linings were in excellent condition after one year of service. Surface linings become damaged quite readily.
- (h) "Controlling Seepage Losses in Irrigation Ditches," by Harold Holmen and E. C. Stegman, North Dakota Agricultural Experiment Station Farm Research, Vol. 21, No. 12, pp. 9-12, July-Aug. 1961, Reprint No. 550.
"Investigation of Seepage Losses in Small Irrigation Canals at the Carrington Irrigation Branch Station," by E. C. Stegman, unpublished M. S. Thesis, North Dakota State University, January 1961.

(3475) SURFACE DRAINAGE.

- (b) Laboratory project.
- (c) Mr. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
- (d) Field investigation; applied research.
- (e) Soil accumulation in field ditches resulting from wind erosion was measured. Snow accumulation in open drains was studied.
- (g) To prevent snow accumulation in open drains, they should be constructed in the direction of the prevailing winds which blow during winter months. Outlets, especially culverts and bridges detained drainage in the spring because snow and debris tended to accumulate at these places.

(4175) WATER INTAKE RATES AND PHYSIOCHEMICAL PROPERTIES OF IRRIGABLE SOILS.

- (b) Joint laboratory project between Department of Agricultural Engineering and Department of Soils.
- (c) Mr. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
- (d) Experimental, basic research, and Master's thesis.
- (e) Intake rates of irrigated soils are being measured by the inflow-outflow method, the double ring infiltrometer, and by the Purdue sprinkling infiltrometer. The change in intake rates caused by land leveling, tillage practices, seasonal change, and compaction from haying machinery and tillage

implements is being studied. The physical and chemical properties and the moisture profile of the soil are being measured before, during, and after irrigations.

NORTHWESTERN UNIVERSITY, The Technological Institute.

(2586) DISPERSION OF FLUID IN POROUS MEDIA.

- (b) Laboratory project; Pure Oil Company.
- (c) Prof. John A. Logan, Dept. of Civil Engrg., Northwestern University, Evanston, Illinois.
- (d) Theoretical experimental; Masters Thesis project of Robert F. H. Owston.
- (e) A study of the mechanics of dispersion of fluid flowing in a trapezoidally confined porous medium. Where a wide included angle is employed the results for a trapezoidal analysis should approximate to those for the radial case, and by reducing the angle until a parallel sided condition be obtained, with the previously investigated straight column problem.
- (f) Completed.
- (g) Two-dimensional flow patterns through a porous medium such as employed in this experiment are apparently microscopically governed. Macroscopic analysis of such phenomena leads to a situation where the physical limitations of the apparatus are such that the results have little consistency and may be considered to bear only a very generalized relationship to the actual phenomena.
- (h) "Dispersion of Two-Dimensional Fluid Flow Through a Porous Media," by Robt. F. H. Owston, Civil Engineering Dept., Northwestern University, M. Sc. Thesis, December 1961.

(3476) FLOOD WAVE ROUTING.

- (b) Northwestern Technological Institute.
- (c) Prof. W. S. Hamilton, Dept. of Civil Engrg., Northwestern University, Evanston, Ill.
- (d) Theoretical and analytical for doctoral and masters theses.
- (e) The purpose is to calculate the movement of flood waves in prismatic and natural channels. Finite difference equations based on (a) method of characteristics and (b) basic equations of momentum and continuity are to be programmed separately for solution on a digital computer.
- (g) It has been found best to use difference equations along characteristics near the upstream and downstream boundaries and a backward difference method based directly on momentum and continuity equations and a rectangular grid for the region not near the boundaries. Program written and verified for IBM 650.
- (h) Theses in preparation.

(3477) THE EFFECT OF JET MIXING ON SEDIMENTATION EFFICIENCY.

- (b) Northwestern University, Technological Inst.
- (c) Prof. Robert Kersten, Chairman Dept. of Civil Engineering, Arizona State University, Tempe, Arizona.
- (d) Theoretical and experimental.
- (e) The study is concerned with the effect of mixing, caused by a two-dimensional jet, on the percentage of particles removed in a rectangular sedimentation basin. Liquid flow, transporting solid particles, is introduced through a slot at the entrance of a long channel. Slot opening and elevation can be varied. The amount of solid particle removal, as well as the distribution of particles on the bottom is measured.
- (f) Completed.
- (g) The amount of material removed is very sensitive to inlet conditions, in particular the ratio of the settling velocity to the jet velocity and the elevation of the jet above the floor. A high jet increases the

removal. The removal is insensitive to the distribution of eddy diffusivity. Calculations by relaxation techniques give results in good agreement with experiment.

(h) "The Effect of Jet Mixing on Sedimentation Removal Efficiency," by R. D. Kersten, Ph.D. Thesis, Northwestern University, Evanston, Illinois, June 1961.

(3789) THE HYDROMECHANICS OF A HIGH VELOCITY GAS JET PENETRATING A LIQUID SURFACE.

- (b) Laboratory project; Bureau of Ships, Dept. of the Navy.
- (c) Prof. Thomas P. Anderson, Gas Dynamics Laboratory, Northwestern University, Evanston, Illinois.
- (d) Theoretical and experimental.
- (e) The cavity formed by a gas jet impinging on a liquid jet is being studied and particularly with regard to stability and sputtering phenomena. Both axisymmetrical and rectangular jets are being considered.
- (g) The size and shape of the cavities resulting from axisymmetric and rectangular jets have been measured and correlated. The stability of the cavity and the onset of sputtering have been found to be particularly sensitive to liquid surface wave interactions.

(3790) TURBULENCE CHARACTERISTICS OF A SUBMERGED LIQUID JET.

- (b) Laboratory project.
- (c) Prof. S. G. Bankoff and Dr. J. E. Sunderland, The Technological Institute, Northwestern Univ., Evanston, Illinois.
- (d) Basic experimental research; doctoral thesis.
- (e) Using the recently developed Hubbard-Ling hot-film anemometer, the time-average velocity profiles and the correlation coefficients will be measured for a submerged, round, free liquid jet.

(3791) ZERO-GRAVITY, TWO-PHASE FLUID MECHANICS.

- (b) Laboratory project.
- (c) Prof. S. G. Bankoff, Technological Inst., Northwestern Univ., Evanston, Illinois.
- (d) Basic experimental research; doctoral thesis.
- (e) The development of the two-phase boundary layer in the flow of a liquid past a porous plate through which a second immiscible liquid is injected is studied. Electrical resistance probes are used for determination of the position of the region boundaries. This simulates zero-gravity boiling heat transfer from a flat plate.
- (f) Inactive.

(3792) RESPONSE OF A BOILING CHANNEL TO INPUT FLUCTUATIONS.

- (b) Laboratory project.
- (c) Prof. S. G. Bankoff, The Technological Inst., Northwestern University, Evanston, Illinois.
- (d) Basic theoretical research; doctoral thesis.
- (e) A recently presented variable-density, single-fluid model for two-phase flow in pipes and channels under steady-state conditions is adapted to the study of the response of a channel to fluctuations of input power or flow.

(3793) VOID FRACTION PROFILES IN TWO-PHASE MERCURY-GAS FLOW.

- (b) Argonne National Laboratory.
- (c) Prof. S. G. Bankoff, The Technological Inst., Northwestern University, Evanston, Illinois.
- (d) Experimental basic research; doctoral thesis.
- (e) Measurement of isothermal steady-state void fraction profiles in concurrent flow of mercury and air by means of electrical resistance probe.

(3796) AN INVESTIGATION INTO THE MECHANISM OF FREEZE DRYING.

- (b) Quartermaster Corps, U.S. Army.
(c) Dr. J. E. Sunderland, Technological Inst., Northwestern University, Evanston, Illinois.
(d) Experimental and theoretical; basic research on M.S. & Ph.D. level.
(e) This is a study of heat and mass transfer problems encountered with freeze drying. One problem is to determine the conditions for the flow through the dried substance to be due to a concentration gradient, or else a total pressure gradient. In other words, is the flow of vapor due to diffusion, or hydrodynamic type flow. In addition, the emissivity and thermal conductivity of meat have been measured.
(g) Several progress reports are available and may be obtained from the correspondent.
- (3797) HEAT CONDUCTION AND CONVECTION PROBLEMS ASSOCIATED WITH MELTING.
(b) Laboratory project.
(c) Dr. J. E. Sunderland, Technological Inst., Northwestern University, Evanston, Illinois.
(d) Theoretical; basic research; Ph.D. thesis.
(e) A study is being carried out to determine the velocity and temperature distribution in the melted layer of a melting body.
(g) The velocity and temperature distribution have been determined for conditions in which the free surface is exposed to a slow force or when a uniform body force exists throughout the melted layer.
- (3798) BOUNDARY LAYER TURBULENCE.
(b) Laboratory project.
(c) Mr. George G. Lamb, The Technological Inst., Northwestern University, Evanston, Illinois.
(d) Theoretical and experimental; basic research.
(e) To develop model based on origin of turbulence in boundary layers that may be extended to permit quantitative understanding of momentum transfer and velocity profiles in turbulent boundary layers.
(g) A model based upon a critical time ratio involving molecular properties and flow parameters shows promise towards understanding and predicting transport properties in turbulent flow in circular pipes and in general turbulent boundary layer flow.
- (3799) FORCES ON SUBMERGED BODIES IN UNSTEADY MOTION.
(b) Northwestern Technological Institute.
(c) Professor W. S. Hamilton, Dept. of Civil Engineering, Northwestern University, Evanston, Illinois.
(d) Theoretical and experimental; for doctoral thesis.
(e) The purpose is to evaluate forces acting on accelerating submerged bodies in a fluid and apply the results to the motion of the snow and dust particles in the atmospheric boundary layer. The theoretical investigations will include the determination of the forces acting on arbitrarily accelerating plates and spheres by using boundary layer theory. Experiments will be conducted for an accelerating sphere in a quiet fluid and data will be correlated.
(g) The forces acting on an arbitrarily accelerating infinitely long plate have been determined theoretically.
- (3801) THE DETERMINATION OF FORM DRAG AND SKIN FRICTION FACTORS IN THE FLOW OF GASES THROUGH EXPANDED FIXED BEDS OF SPHERICAL PARTICLES.
(b) Doctoral Dissertation (C.A. Wentz).
(c) Prof. George Thodos, Dept. of Chemical Engrg., Northwestern University, Evanston, Illinois.
(d) Experimental.
(e) Expanded fixed beds have been prepared by attaching phenolic spheres ($d = 1.25$ inches) with rigid fine wires in order to produce a composite structure having different void fractions. A test sphere is located in the center of this structure. This sphere is provided with means for obtaining the static pressure distribution around the spherical surface. With this experimental information, the form drag can be accounted for and when subtracted from the total drag, the shear drag is obtained.
(f) Inactive.
- (4176) COMBUSTION DELAY TIME AND FLAMEHOLDER FLUID DYNAMICS.
(b) Laboratory project.
(c) Mr. George G. Lamb, The Technological Inst., Northwestern University, Evanston, Illinois.
(d) Theoretical and experimental; basic research.
(e) To develop theoretical understanding of chemical kinetics of combustion reactions involving high energies of activation and reaction, combined with fluid dynamic transport phenomena.
(h) "Chemical and Physical Kinetics of Combustion of Fuels in Internal Combustion Engines," by G. G. Lamb and D. P. Lamb, Division of Petroleum Chemistry Amer. Chem. Soc. Preprints, 6:3:B-73-83, (8/61).
- UNIVERSITY OF NOTRE DAME, Dept. of Civil Engineering.
- (3803) POTENTIAL ANALOG SIMULATION OF DEFORMABLE HYDRODYNAMIC BOUNDARIES.
(b) National Science Foundation.
(c) Dr. A. G. Strandhagen, Dept. of Engineering Science, University of Notre Dame, Notre Dame, Indiana.
(d) Project is both experimental and theoretical, and is of a basic research type. Two master's degree candidates and one doctoral candidate are active in this investigation.
(e) Two-dimensional conducting sheet is used to simulate the flow around submerged bodies moving below a free surface. Flow past cavitating hydrofoils, flat-plate hydrofoils, and shaped hydrofoils are under investigation.
(g) Experimental or analog results are in agreement with analytical results for flow around a flat plate and also for a vortex below a free surface. The solution to a cavitating hydrofoil is under investigation.
(h) "Analog Studies of Free Surface Problems," by A. G. Strandhagen and A. Welsh, Fifth Midwestern Conference on Fluid Mechanics, 1961.
- (4177) BIBLIOGRAPHY OF HYDRAULICS OF OPEN CHANNELS.
(b) Research work submitted for a grant from the National Science Foundation.
(c) Dr. S. Kolupaila, Dept. of Civil Engineering, Notre Dame, Indiana.
(d) Bibliographical research.
(e) Work was initiated as a continuation of the "Bibliography of Hydrometry," published by the University of Notre Dame in 1961. Chapters: basic principles; uniform flow; gradually varied flow; rapidly varied flow; unsteady flow.
(f) Discontinued.
- (4178) DEVICES AND METHODS OF VELOCITY MEASUREMENTS AT SEA.
(b) Research work submitted for a grant from the U. S. Navy.
(c) Dr. S. Kolupaila, Dept. of Civil Engineering, Notre Dame, Indiana.
(d) Historical and bibliographical survey.
(e) Description of all principles and instruments accompanied by original illustrations, based on existing literature in many languages.
(f) Discontinued.
- (4179) RIVER HYDROLOGY, SURVEY AND SELECTED BIBLIOGRAPHY.
(b) Research work submitted for a grant from the

- (c) National Science Foundation.
Dr. S. Kolupaila, Dept. of Civil Engineering,
Notre Dame, Indiana.
- (d) Bibliographical research.
- (e) Historical and bibliographical survey.
Contents: historical development of river
hydrology; river morphology; runoff; floods;
winter regime; river hydraulics; sediment
transportation; river crossings; runoff
regulation; geographical distribution;
runoff variations; river investigations.

OHIO STATE UNIVERSITY, Department of Civil Engrg.

- (3030) TRANSIENT FLOW THROUGH POROUS INCOMPRESSIBLE
MEDIA WITH VARIOUS BOUNDARY CONDITIONS.
- (b) Experimental part was supported by the
National Research Council of Canada.
- (c) Dr. B. S. Browzin, Ohio State University,
2036 Neil Avenue, Columbus 10, Ohio.
- (d) Experimental and theoretical; basic research.
- (g) Experimental part concerning earth dams and
earth massives on impervious foundations
completed. The theoretical part of the
research completed for the case of rapid
drawdown in homogeneous dams. The theo-
retical research of cases of gradual draw-
down, of non-homogeneous dams, of tailwater
condition, and the drawdown in canals is
progressing.
An approximate function relating, by
dimensionless parameters, the shape and
the position of free surface of flow
through the earth dam, following rapid
reservoir drawdown, to the geometry of the
dam was obtained theoretically and confirmed
by experiments.
- (h) "Nonsteady-State Flow in Homogeneous Earth
Dams after Rapid Drawdown," Proceedings of
the Fifth International Conference on Soil
Mechanics and Foundation Engineering, 1961,
Vol. II, p. 551-554.

- (3031) THE VARIATION OF HYDROLOGIC FACTORS AND
THEIR INFLUENCE ON RIVER REGIMES IN THE
GREAT LAKES-ST. LAWRENCE DRAINAGE AREA.
- (b) Partially sponsored by the OSU Experiment
Station.
- (c) Dr. B. S. Browzin, Ohio State University,
2036 Neil Avenue, Columbus 10, Ohio.
- (d) Basic research.
- (e) Research is based on long range flow and
meteorologic record. Flow and precipitation
data on U.S. and Canada stations were
statistically investigated in order to
obtain river regime characteristics. Other
climatic, geologic and botanic data, will
be included, depending on availability.
- (g) Classified discharges and precipitation
for long range gaging and meteorologic
stations are calculated. Characteristic
parameters for river classification of the
area are obtained.

OKLAHOMA STATE UNIVERSITY, Agricultural Engineering
Department.

- (2365) HYDROLOGIC STUDIES ON SMALL GRASS-COVERED
WATERSHEDS.
- (b) Agricultural Experiment Station cooperative
with Agricultural Research Service.
- (c) Prof. F. R. Crow, Okla. State Univ., Dept.
of Agricultural Engrg., Stillwater, Okla.
- (d) Field investigation; applied research.
- (e) Measurements are being made to provide
hydrologic data on total watershed runoff
and peak rates of runoff from three small
grass-covered watersheds (17 to 206 acres)
in north central Oklahoma. Highway culverts,
modified by the addition of weir sills, are
being used as runoff measuring devices.
- (g) Intensive model tests of culverts equipped

with weir sills completed. Ten year data
on precipitation and runoff completed.

- (2828) THE EFFECTIVENESS OF MONOMOLECULAR FILMS
FOR REDUCING EVAPORATION FROM RESERVOIRS.

- (b) Oklahoma Agricultural Experiment Station.
- (c) Prof. F. R. Crow, Oklahoma State Univ.,
Dept. of Agricultural Engineering,
Stillwater, Oklahoma.
- (d) Experimental; applied research.
- (e) Studies are being made on plastic lined
experimental evaporation reservoirs to
develop methods of application and determi-
nation of effectiveness of hexadecanol and
octadecanol films for reducing evaporation.
- (g) Evaporation reductions of 25 to 40% have
been obtained using a slurry method of
applying film to experimental pond. Curves
have been developed relating wind speed and
required film application rate.
- (h) "Reducing Reservoir Evaporation," by F. R.
Crow, Agricultural Engineering, Vol. 42,
No. 5, May 1961.

- (3804) THE HYDRAULICS OF CONSERVATION CHANNELS.

- (b) Agricultural Research Service, U.S. Dept.
of Agriculture in cooperation with the
Oklahoma Agricultural Experiment Station.
- (c) Mr. W. O. Ree, Agr. Research Service, Soil
and Water Conservation Research Div.
Southern Plains Branch, Stillwater, Okla.
- (d) Experimental; applied research.
- (e) Vegetation lined waterways of the kind used
to convey short duration flood flows from
small watersheds are constructed full size
on the grounds of an outdoor hydraulic
laboratory. Flow tests are made on these
experimental channels to determine the
protective ability of various grasses
and to evaluate the flow friction factors
under different conditions of growth.
Perennial for the temporary protection of
newly constructed earth waterways are both
considered in these studies. Temporary
liners of various fibers including jute,
paper, and glass are also tested.
- (g) Manning's n values have been determined for
various grass species. The physical
characteristics of the vegetation and the
flow character both influence the flow
retardance factor so special design diagrams
have been prepared to aid in solving flow
problems under these conditions.

OREGON STATE COLLEGE, Hydraulics Laboratory.

- (3805) OPEN CHANNEL JUNCTIONS FOR SUPERCRITICAL
FLOW.

- (b) U. S. Dept. of Commerce, Bureau of Public
Roads.
- (c) Prof. C. E. Behlke, Dept. of Civil Engrg.,
Oregon State University, Corvallis, Oregon.
- (d) Theoretical and experimental; applied
research.
- (e) Wave effects resulting from the junction
of two supercritical, open channel flows
are being studied to determine the magnitude
and the location of the wave pile up on the
channel walls. Only rectangular channels
are presently being considered. Trape-
zoidal channels will be considered later.

THE PENNSYLVANIA STATE UNIVERSITY, Ordnance Research
Laboratory, College of Engineering and Architecture,
University Park, Pennsylvania, Dr. John C. Johnson,
Director. Work done under Dr. G. F. Wislicenus,
Director of the Garfield Thomas Water Tunnel.

- (2832) MEASUREMENT OF FORCES ON A MODEL IN A
WATER TUNNEL.
- (b) Laboratory project sponsored by the Bureau

- of Naval Weapons.
- (c) Messrs. G. B. Gurney and T. E. Peirce, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental; developmental.
- (e) The problem concerns the measurement of forces on models in a water tunnel over a velocity range up to 80 feet per second, pressure ranges of 3 to 60 pounds per square inch absolute.
- (g) Two four component (lift, axial force, pitching and rolling moment) balances for use in water tunnels utilizing strain gaged pre-tensioned flexure beams as the force sensing devices have been in successful operation for three years. Development of a Planar Motion Mechanism is now underway. The Planar Motion Mechanism will be capable of imparting pure pitching and heaving motions to models to permit the experimental determination of all the hydrodynamic stability coefficients required in the equations of motion for a submerged body with four (4) degrees of freedom. These equations include the static, damping and acceleration derivatives. Measurements of unsteady forces on propulsors have recently been made.
- (3143) REDUCTION OF SKIN FRICTION DRAG.
- (b) Joint program of investigation with the General Electric Company, the United States Rubber Company and the Northrop Corporation sponsored by the Bureau of Naval Weapons.
- (c) Dr. John Lumley and Mr. John McMahon, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental, basic research; theoretical and applied research.
- (e) Investigations into the application of boundary layer control through suction and compliant surfaces for underwater bodies.
- (g) Successful probe (.005 inch resolution, 5 KC response) and associated electronic gear developed.
- (3486) TURBULENCE MEASUREMENTS IN WATER.
- (b) Laboratory project sponsored by the Bureau of Naval Weapons.
- (c) Dr. John Lumley, Ordnance Research Lab., University Park, Pennsylvania.
- (d) Experimental.
- (e) Using a constant temperature probe, some turbulent flows at high Reynolds numbers will be investigated with particular attention to homogeneous grid-produced turbulence and turbulent dispersion in a shear flow.
- (g) Measurements have been taken in a small water tunnel settling section determining the effect of various screens and honeycombs on turbulence.
- (3487) FLOW DISTORTION FEEDING INTO A PROPELLER.
- (b) Laboratory project sponsored by the Bureau of Naval Weapons.
- (c) Mr. J. J. Eisenhuth, Ordnance Research Lab., University Park, Pennsylvania.
- (d) Theoretical and experimental.
- (e) This is a study of the interaction effects between control surfaces and a propeller when the surfaces are located in front of the propeller and feed a distorted flow into it. The primary goal is to determine how effectively the propeller cancels the forces produced by the control surfaces.
- (3488) FLOW OVER A BODY OF REVOLUTION WITH STABILIZING SURFACES.
- (b) Laboratory project sponsored by the Bureau of Naval Weapons.
- (c) Mr. E. J. Rodgers, Ordnance Research Lab., University Park, Pennsylvania.
- (d) Theoretical and experimental.
- (e) This study is directed toward the understanding of the flow conditions around a body of revolution with stabilizing fins
- under conditions of pitch and/or yaw. The eventual goal is to be able to predict more precisely the hydrodynamic coefficients of such a body by virtue of a better understanding of the flow conditions.
- (3807) INVESTIGATION OF THE CAVITATION CHARACTERISTICS OF A FEW SIMPLE LIQUIDS.
- (b) Laboratory project sponsored by NASA.
- (c) Mr. A. F. Lehman, Ordnance Research Lab., University Park, Pennsylvania.
- (d) Experimental, analytical; basic research.
- (e) To investigate experimentally the cavitation characteristics of a few simple (as regards to vapor pressure and handling) liquids under conditions occurring in space and aircraft pumping machinery, and analyze the results so that a reliable basis for theory applicable to these conditions can be formulated.
- (g) A small high speed water tunnel having test section velocities of 300 feet per second, pressures to 500 pounds per square inch, temperatures to 250 degrees Fahrenheit has been designed, constructed and will be in operation by January 1962.
- (4180) UNSTEADY FLOW INVESTIGATIONS AROUND AN ELLIPSOID OF REVOLUTION.
- (b) Laboratory project sponsored by Bureau of Naval Weapons.
- (c) Mr. Maurice Sevik, Ordnance Research Lab., University Park, Pennsylvania.
- (d) Experimental and theoretical study of unsteady forces acting on an ellipsoid of revolution over a range of Reynolds numbers and body attack angles. Instantaneous values of forces and moments have been measured for Reynolds numbers up to 10^7 in a water tunnel with body attack angles of zero, 5 and 10 degrees. Further measurements are planned with the ellipsoid performing small oscillations in a direction normal to the main flow.
- (4181) DETERMINATION OF EFFECT OF TUNNEL BOUNDARIES ON THE FORCES ACTING ON A MODEL.
- (b) Laboratory project sponsored by Bureau of Naval Weapons.
- (c) Mr. Thomas Peirce, Ordnance Research Lab., University Park, Pennsylvania.
- (d) Theoretical and experimental.
- (e) Investigation of the errors introduced by the physical boundaries of tunnel walls on the measured forces on large models. The investigation covers both the axially symmetric case and when the models are at low angles of attack. Establishing the means for correcting these errors is also a part of this investigation.
- (g) For the axially symmetric case the installation of a tunnel liner has produced satisfactory results.
- (h) "Elimination of Water-Tunnel Interaction with a Coaxial Test Body by a Flow-Correcting Liner and Application to the Test of an Albacore Model," by A. F. Lehman, J. H. Light, and T. E. Peirce, July 25, 1958, ORL Report NORD 16597-39.
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- PURDUE UNIVERSITY, Agricultural Experiment Station.
- (2596) THE USE OF A RAINFALL SIMULATOR FOR SOIL AND WATER MANAGEMENT STUDIES.
- (b) Soil and Water Conservation Research Div., Agricultural Research Service, USDA and Purdue University.
- (c) Mr. L. Donald Meyer, Agricultural Engineer, ARS-USDA, Agricultural Engineering Building, Purdue University, Lafayette, Indiana.
- (d) Field investigation; applied research.
- (e) The rainfall simulator is used on runoff plots for comparison of treatments which

- affect erosion and infiltration. Research includes studies of tillage methods, crop residue management, slope, soil type, crop rotations, and intensity histograms.
- (h) "Use of the Rainulator for Runoff Plot Research," by L. Donald Meyer, Soil Sci. Soc. Am. Proc. 24 (4):319-322. 1960.
- "Soil and Water Conservation Research with the Rainulator," by L. D. Meyer and J. V. Mannering. Seventh Int. Soil Sci. Soc. Congress Proc. August 1960.
- "Minimum Tillage for Corn: Its Effect on Infiltration and Erosion," by L. D. Meyer and J. V. Mannering, Agricultural Engineering 42 (2):72-75, February 1960.
- "Effects of Different Methods of Cornstalk Residue Management on Runoff and Erosion as Evaluated by Simulated Rainfall," by J. V. Mannering and L. D. Meyer, Soil Sci. Soc. Am. Proc. 25 (6). November 1961.
- (2597) THE EFFECTS OF TILLAGE ON RUNOFF AND EROSION.
- (b) Laboratory project.
- (c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
- (d) Field investigation; applied research.
- (e) Runoff is measured from 15 watersheds in five different tillage systems. These systems involve two surface soil treatments and three subsoil treatments, including subsoil fertilization and vertical mulching. Hydrologic analyses of these small watersheds are used to evaluate the effects of tillage on soil moisture, crop growth and yield, and runoff.
- (2835) PRELIMINARY INVESTIGATION OF WATER TABLE IN SANDY SOIL.
- (b) Laboratory project.
- (c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
- (d) Field investigation; applied research.
- (e) The water table in a sandy field is controlled from an adjacent supply ditch in which the water level is kept high. Depths to the water table are continuously measured during the growing season at various distances from the ditch and correlated with crop yield data.
- (2837) TREATMENT OF SURFACE WATERS FOR DOMESTIC USE ON THE FARM.
- (b) Laboratory project.
- (c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
- (d) Field investigation; applied and basic research.
- (e) The treatment of pond water by use of slow sand and diatomaceous earth filters is being evaluated. Improved designs are under investigation.
- (3490) INVESTIGATION OF FLOW CHARACTERISTICS IN DRAIN TILE AND THE RELATIONSHIP OF THESE FLOW CHARACTERISTICS TO SEDIMENTATION.
- (b) Laboratory project.
- (c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
- (d) Experimental; basic research.
- (e) Flow of water through a partially filled transparent drain is being observed on steep slopes. Three regimes of flow below a hydraulic jump which is made to occur on these slopes are being studied to determine their effect on the design of circular drains.
- (h) "The Transition From Part-Full to Full Flow in Steep Circular Drains," by W. D. Lembke, Ph.D. Thesis, Purdue University Library, 1961.
- (3808) DEVELOPMENT AND REFINEMENT OF METHODS FOR ESTIMATING FIELD RUNOFF AND SOIL LOSS.
- (b) Soil and Water Conservation Research Div., USDA, and Purdue University.
- (c) Mr. Walter H. Wischmeier, ARS-SWC, Agric. Engineering Dept., Purdue Univ., Lafayette, Indiana.
- (d) Experimental; development.
- (e) The relationships of numerous rainstorm characteristics, topographic features, soil characteristics and surface conditions to field runoff and soil erosion are being evaluated from plot data obtained under natural rainfall. Basic plot and small watershed data on an individual storm basis have been assembled in an ARS central runoff and soil-loss data laboratory at Purdue Univ., from 23 states. The data represent results of cooperative research studies over the past 32 years at 45 locations.
- (g) A rainfall-erosion index has been derived which evaluates numerically the capacity of specific combinations of rainstorm characteristics to erode soil from farm fields. About 200 station rainfall records in the contiguous United States were analyzed to obtain probability values of the erosion index by geographic areas. Iso-erodent maps were prepared from these data. Locality rainfall patterns were also analyzed with respect to the expected distribution of erosive rainstorms within the year. Results were summarized as erosion-index curves for specified geographic areas. A soil-loss prediction procedure was developed which provides guide lines for conservation farm planning. Derivation of information needed for localized evaluations of the factors in the soil-loss equation is continuing.
- (h) "Distribution of Rainfall Erosion Potential in the United States," by W. H. Wischmeier, ASAE paper No. 61-228, 1961.
- (4182) THE MECHANICS OF EROSION BY RAINFALL AND SHEET RUNOFF.
- (b) Soil and Water Conservation Research Div., Agricultural Research Service, USDA and Purdue University.
- (c) Mr. L. Donald Meyer, Agricultural Engineer, ARS-USDA, Agricultural Engineering Building, Purdue University, Lafayette, Indiana.
- (d) Experimental; basic research.
- (e) The splash and runoff of simulated soil particles from an area 0.6 meters wide by 3.0 meters long will be investigated. Variables during the initial phases include particle size, inclination of slope, rate of sheet runoff, and simulated rainfall.
- (4183) SUBSURFACE DRAINAGE OF BLOUNT SILT LOAM.
- (b) Laboratory project.
- (c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
- (d) Field investigation; applied research.
- (e) Various spacings between parallel subsurface drains are under investigation to determine their effectiveness in water removal and crop response. Continuous records of tile discharge are being made and crop yields are determined at harvest time.
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- PURDUE UNIVERSITY, Department of Agronomy.
- (4184) DYNAMICS OF WATER FLOW IN TILE-DRAINED LAND.
- (b) Laboratory project.
- (c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue University, Lafayette, Ind.
- (d) Experimental; basic research for a Master's thesis.
- (e) An important aspect of flow in tile drainage systems is the movement of water through

- water-saturated porous media. Boiled, deionized water, with and without 0.1% phenol, was passed through liquid-saturated quartz sands in laboratory permeameters. The hydraulic conductivity of the sand was calculated, and observed as a function of the volume of liquid passed through the sand. After flow was terminated, the number of bacteria in successive sections of the permeameters was determined by plate count methods.
- (f) Completed.
- (g) With boiled, deionized water at room temperature, the hydraulic conductivity of the sand decreased several orders of magnitude as flow continued. The conductivity decrease could be essentially eliminated either by phenol in the water, or by low temperature (1.5 degrees C.). The conductivity decrease was in all cases strikingly related to the number of bacteria found in the sand.
- (h) "Flow-Associated Reduction in the Hydraulic Conductivity of Quartz Sand," by R. P. Gupta and D. Swartzendruber, Soil Sci. Soc. Amer. Proc. 26, No. 1, Jan.-Feb., 1962 (In press).
- (4185) ANALYSIS OF THE DYNAMICS OF MOISTURE FLOW IN SOILS.
- (b) Laboratory project.
- (c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue University, Lafayette, Ind.
- (d) Theoretical and experimental; basic and applied.
- (e) The effect of relatively open subsoil channels (as occur in vertical mulching) on the infiltration of water into soil was studied both by means of a mathematical solution in elliptic integrals, and by a small-scale laboratory sand model. A second study considered the validity of Darcy's law for porous media containing clay, using data available in the literature.
- (g) The mathematical solution indicated that the relatively open subsoil channel appreciably increases the infiltration rate only if the channel (1) penetrates through a nearly impermeable layer at the soil surface, or (2) penetrates deeply enough to closely approach a very highly permeable substratum such as gravel. The model studies also showed the channels to be effective when water moves into a soil at very low moisture content. From the second study, it was found for the data of four independent investigators that Darcy's law did not hold. A modified, two-parameter flow equation was proposed, which was found to fit the data; and the resulting parameters were found to behave consistently. The modified behavior is accounted for on the basis of non-Newtonian flow behavior.
- (h) "Water Movement into Soil from Idealized Vertical Mulch Channels," by D. Swartzendruber, Soil Sci. Soc. Amer. Proc. 24, No. 3, Pages 152-156, 1960.
- "Modification of Darcy's Law for the Flow of Water in Soils," by D. Swartzendruber, Soil Science 93, No. 1, Jan. 1962 (In press).
- (4186) MECHANISMS OF HYDRAULIC CONDUCTIVITY DECREASE IN WATER-SATURATED SOILS.
- (b) Laboratory project and Purdue Research Foundation.
- (c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue University, Lafayette, Ind.
- (d) Experimental; basic research for Ph.D. thesis.
- (e) An experimental study of factors responsible for reducing the hydraulic conductivity of water-saturated porous media, with special emphasis upon entrapped gases (particularly air) and bacteria. The content of entrapped gases will be evaluated by a compression technique.
- (4187) VISCOUS FLOW OF WATER IN CLAY SYSTEMS.
- (b) Laboratory project.
- (c) Dr. P. F. Low, Prof. Agronomy Dept., Purdue University, Lafayette, Indiana.
- (d) Experimental; for doctoral thesis.
- (e) Darcy's equation has been experimentally verified for relatively high rates of flow. However, there is some question regarding its validity for low rates of flow. Attention will be focused on the viscosity variable in the equation. Recent evidence obtained in this laboratory indicates that water in the vicinity of clay mineral surfaces has a structure different from that of normal water. Since viscosity is a structure-sensitive property of a fluid, it is likely that the viscosity of the water in the clay system is different from that of normal water. It is the purpose of this investigation to ascertain whether or not there is a threshold gradient below which water flow will not occur in a clay-water system. In addition, it is the purpose of this experiment to determine if a non-linearity between Q and 1 exists for low values of 1 .
- (g) Preliminary results only.
- (h) "Viscosity of Water in Clay Systems," by Philip F. Low, Proc. of Eighth National Conference of Clays and Clay Minerals, pp. 170-182, 1960.
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- PURDUE UNIVERSITY, Chemical Engineering Department.
- (3809) SHEAR TRANSFER FROM MOVING GAS TO VISCOUS LIQUIDS.
- (b) Department project.
- (c) Prof. W. H. Tucker, Chemical and Metallurgical Building, Purdue Univ., Lafayette, Ind.
- (d) Experimental; design and applied research, master's and doctoral theses.
- (e) Measurement of friction factors and surface velocities and their effects on mass transfer within liquids of different surface tensions.
- (g) The surface tension of a liquid has been found to greatly influence the degree of contact between a moving gas and the liquid.
- (h) "Residence-Time Studies in a Con-current Wetted-wall Column," by L. Subbaiyan, M.S. Thesis, Purdue Univ., January 1962.
- (3810) THE EFFECTS OF SURFACE ROUGHNESS ON HEAT, MASS, AND MOMENTUM TRANSFER.
- (b) National Science Foundation.
- (c) Mr. J. E. Myers, School of Chemical Engrg., Purdue University, Lafayette, Indiana.
- (d) Experimental and theoretical; basic research for Ph.D. theses.
- (e) Experimental measurements were made of effects of solid geometry and fluid properties on form drag, skin friction, and heat transfer coefficients in flow of water over circular fins in a pipe.
- (g) Two doctoral theses completed; work continuing.
- (4188) SAMPLING OF HETEROGENEOUS FLUIDS IN FLOW.
- (b) American Petroleum Institute.
- (c) Mr. J. H. Rushton, School of Chemical Engineering, Purdue University, Lafayette, Indiana.
- (d) Experimental and theoretical basic research.
- (e) Find basic relations between the distribution of gas in liquid caused by mixers in tanks of different sizes.
- (g) One M.S. and one Ph.D. project being completed.
- (4189) BATCH AND CONTINUOUS THICKENING OF SLURRIES.
- (b) Laboratory project.
- (c) Prof. Paul T. Shannon, School of Chemical Engrg., Purdue University, Lafayette, Ind.
- (d) Theoretical and experimental; basic research for Ph.D. thesis.
- (e) A theoretical analysis of batch and continuous

thickening is presented based on the assumption that the settling rate of the solids relative to the slurry is a function only of the local solids concentration ("ideal" behavior). Equations are derived for the propagation of concentration changes in terms of the solids flux. They relate batch and continuous thickening. Utilizing the flux plot obtained from initial batch settling rate data, a method is presented for predicting the complete batch settling curves and the steady and unsteady state behavior of slurries in a continuous thickener. This approach offers a logical and consistent explanation of many previously unexplained phenomena.

- (g) Batch settling data for CaCO_3 slurries were obtained for concentrations from 10 to 190 g.p.l. and for several weight of solids per unit area. Gamma-ray absorption was used to determine the variation of solids concentration with height and time. The flux plot determined from initial batch settling rates was doubly concave and independent of the weight of solids per unit area. The experimental batch results and published data on continuous thickening showed complete qualitative and close quantitative agreement with the theory. Deviations from "ideal" behavior in both batch and continuous thickening were attributed principally to the effect of varying weight of solids per unit area. A reappraisal of the concept of thickening in compression is presented.
 - (h) E. M. Tory, Ph.D. Thesis, Purdue University, June, 1961.
- (4190) BATCH SEDIMENTATION OF RIGID SPHERES IN WATER.
- (b) Laboratory project.
 - (c) Prof. Paul T. Shannon, School of Chemical Engineering, Purdue University, Lafayette, Indiana.
 - (d) Theoretical and experimental; basic research for M.S. thesis.
 - (e) As part of a continuing study of the solids-fluid mechanics of multiparticle systems, batch settling tests on closely sized, uniform, spherical glass beads in water were performed over the entire range of solids concentration. This work was done to provide a test of the theory previously developed, particularly the basic assumption that the solids settling velocity relative to the slurry is a function only of the local solids concentration. Also, in order to isolate the effects of variable fluid and solid properties in batch and continuous thickening, one must know the behavior of uniform rigid spheres in a newtonian fluid.
 - (g) The solids flux as a function of concentration determined from initial batch settling rates was found to be doubly concave. The batch settling curves were found to have many of the properties previously attributed to the compressibility of the solids. Complete batch settling curves theoretically predicted using the flux plot based in initial rates agreed very well with the experimental results. The slight deviations were attributed to non-uniform initial concentrations and particle size segregation at low concentrations.
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PURDUE UNIVERSITY, School of Civil Engineering.

(2839) HYDRAULICS OF RIVER FLOW UNDER ARCH BRIDGES.

- (b) State Highway Department of Indiana and Bureau of Public Roads.
- (c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
- (d) Experimental; for design and master's theses.
- (e) The purpose of the research is to study systematically the hydraulic efficiency of

waterways under arch bridges, to provide a criterion for determining the proper clear span of arch bridges so as to compensate for the loss of efficiency at high flows, and to provide a method for computing the backwater upstream of arch bridges.

- (g) Preliminary small scale model investigation has been completed. Large scale testing of two and three dimensional semi-circular models in both smooth and rough boundaries including a number of skewed and eccentric ones has been completed. The large scale tests were conducted in a tilting flume 5 ft. wide and 64 ft. long.
 - (h) "Roughness Spacing in Rigid Open Channels," by W. W. Sayre and M. L. Albertson, discussion by P. F. Biery and J. W. Delleur, Journal of the Hydraulics Division Vol. 87, HY5, A.S.C.E., September 1961.
- (2840) MECHANISM OF TURBULENCE IN FREE SURFACE FLOW.
- (b) National Science Foundation, Purdue Research Foundation.
 - (c) Dr. J. W. Delleur and Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engrg., Purdue University, Lafayette, Indiana.
 - (d) Theoretical and experimental: for Ph.D. theses.
 - (e) Analytical and experimental investigation of the mechanism of turbulence in free surface flow. The analytical part of the project will investigate important flow characteristics such as the spectrum of turbulence, correlation of velocities in the turbulent field, degree of isotropy, and the various velocity functions in submerged jet and open channel flow. The experimental portion of the program will make tests coincident with theoretical studies. Several instrument revisions, the construction of water filtering circuits and of a small towing facility is being undertaken.
 - (g) Precision test flume designed. The flume has variable longitudinal slope and changeable cross section. The cross section may be rectangular or trapezoidal with different side slopes. Hot wire anemometer in progress.
 - (h) "Mechanism of Turbulence in Free Surface Flow," by J. W. Delleur, Progress Report No. 1, July 1961.
- (2841) STUDY OF RUNOFF FROM SMALL WATERSHEDS FOR HIGHWAY DRAINAGE DESIGN IN INDIANA.
- (b) State Highway Department of Indiana.
 - (c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
 - (d) Analysis and statistical investigation for Ph.D. thesis.
 - (e) The purpose of the research is to study the hydrology of watersheds less than 200 square miles throughout the State of Indiana, to improve the existing methods for estimating the runoff from small watersheds, and to improve the present methods of design of highway drainage structures servicing small watersheds. A statistical analysis by means of the extreme values method has been completed. Graphical relations which permit derivation of peak flow as function of five geomorphological parameters of the watershed have been prepared.
 - (g) Runoff and rainfall data are being collected, and runoff statistical and geomorphological analysis has been completed.
 - (h) "Study of Runoff from Small Watersheds for Highway Drainage Design in Indiana," I. P. Wu and J. W. Delleur, Progress Report No. 1, May 1961.

(3146) HYDROMECHANICS OF FLUID COLLECTOR SYSTEM IN POROUS MEDIA.

- (b) Purdue Research Foundation.
- (c) Dr. G. H. Toebes, Hydraulic Laboratory,

- School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
- (d) Theoretical, and experimental; for Ph.D. thesis.
 - (e) Analytical and experimental investigations of the gravity flow field around horizontal collector wells.
 - (f) Completed.
 - (g) The exact solution for gravity flow towards a sink strip was derived. Slow convergence of relaxation methods, utilizing a digital computer necessitated the use of an hydraulic model equipped with an electric free surface probe. Results permitted the formulation of a discharge formula as well as a number of design recommendations. A novel method for increasing the well yield, called "vacuum pumping", has been given.
 - (h) "Gravity Flow Towards Horizontal Collector Wells," A. L. Simon, Ph.D. Thesis, Purdue University, January 1962.
- (3147) GEOHYDRAULICS.
- (b) Laboratory project.
 - (c) Messrs. J. W. Delleur and A. L. Simon, Hydraulic Laboratory, School of Civil Engrg., Purdue University, Lafayette, Indiana.
 - (d) Theoretical; basic research.
 - (e) Geohydraulic theory is being developed as a science based on Fluid Mechanics and Hydrogeology. Quantitative analyses are developed. A bibliography includes principal works of European scientists and others.
 - (f) Inactive.
- (3491) NUMERICAL METHODS IN ANALYSIS OF HYDRO-MECHANICS PROBLEM.
- (b) Engineering Experiment Station, Purdue Univ.
 - (c) Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
 - (d) Analytical and applied research for Ph.D. thesis.
 - (e) The purpose of the research is to make available to the hydraulic engineers the mathematical tools which are normally beyond his competence. The techniques of solving numerically flood routing problems is in progress. The emphasis will be on methods making use of electric desk calculators, digital and analog computers.
 - (g) Preliminary computer programs have been completed.
- (3492) TRANSIENT DEVELOPMENT OF THE FREE SURFACE IN A HOMOGENEOUS EARTH DAM.
- (b) Purdue Research Foundation.
 - (c) Dr. M. E. Harr, School of Civil Engineering, Department of Soil Mechanics, Purdue Univ., Lafayette, Indiana.
 - (d) Theoretical for Ph.D. thesis.
 - (e) The study is aimed at the development of a rational treatment of the "rapid drawdown" condition for the analysis of earth and rockfill dams.
 - (f) Completed.
- (3493) SEEPAGE INTO SHEETED EXCAVATION.
- (c) Dr. M. E. Harr, School of Civil Engineering, Department of Soil Mechanics, Purdue Univ., Lafayette, Indiana.
 - (d) Theoretical.
 - (e) The closed form solution of the problem for the factor of safety with respect to heaving of the base of sheeted excavation and the quantity of seepage.
 - (f) Completed.
 - (h) "Seepage Into Sheeted Excavation," Journal of Soil Mechanics and Foundations, A.S.C.E., October 1961.
- (4191) MEANDER-FLOOD PLAIN MODEL.
- (b) Purdue Research Foundation.
 - (c) Dr. G. H. Toebes, Hydraulic Laboratory,
- School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
- (d) Analytical and experimental research for Ph.D. thesis.
 - (e) A 5 x 30 foot styrofoam meander-flood plain model is built with adjustable slope, side walls and channel dimensions. Flow visualization equipment and a directional Prandtl tube are in use. Both stage-discharge relations as well as internal flow field characteristics are being investigated.
 - (g) The literature concerning meander mechanisms has been reviewed. Several experimental stage-discharge relations are available.
- (4192) PERFORMANCE CHARACTERISTICS OF EAGLE CREEK RESERVOIR SPILLWAY.
- (b) Dodson, Kinney and Linblom, consultants to the Indianapolis Flood Control District.
 - (c) Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
 - (d) Experimental, design.
 - (e) The overflow spillway for Eagle Creek reservoir near Indianapolis, with a design discharge of 160,000 cfs is situated only 700 feet from a major Interstate Highway. The road will at larger flow act as a broad crested weir giving rise to an unusually flat tailwater rating curve.
 - (g) Tests have led to several modifications of the original design.
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- PURDUE UNIVERSITY, School of Electrical Engineering.
- (3494) AN INVESTIGATION OF THE FEASIBILITY OF A MAGNETICALLY CONTROLLED POPPET VALVE HYDRAULIC SERVOMECHANISM.
- (b) Laboratory project.
 - (c) Prof. J. E. Gibson, School of Electrical Engineering, Purdue University, Lafayette, Indiana.
 - (d) Experimental and analytical; basic research for Master's Thesis.
 - (e) This project includes the design, analysis, and experimental testing of a method of controlling a hydraulic - mechanical energy converter by means of a time varying pressure source and two electro-magnetic poppet valves.
 - (g) Method has proved feasible to a limited degree.
 - (h) "An Investigation of an Electromagnetically Controlled Poppet Valve for use in Pulse Length Modulated Hydraulic Automatic Control Systems," by David E. Boddy, M.S. Thesis, Purdue University, 109 p., August 1960.
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- PURDUE UNIVERSITY, Jet Propulsion Center.
- (2374) THE MECHANISM OF TWO-PHASE FLOW OF ANNULAR LIQUIDS IN A VERTICAL TUBE.
- (b) Office of Naval Research, Dept. of the Navy.
 - (c) Dr. M. J. Zucrow, Jet Propulsion Center, Purdue University, Lafayette, Indiana.
 - (d) Experimental and theoretical; basic research for masters degrees.
 - (e) This problem is concerned with the analytical and experimental study of the mechanism of the downward flow of a liquid film on the inside wall of a vertical circular tube with co-current gas flow in the core of the tube. Systematic experiments are being conducted for determining the effect of the rates of air flow and liquid flow upon the velocities of the interfacial waves on the surface of the liquid film. In addition attempts are being made to measure the starting length required to establish characteristic interfacial waves on the surface of the liquid film.
 - (h) "Investigation of Annular Two-Phase Flow,

and Heat Transfer to and From Gases with Large Temperature Differences," by C. F. Warner and J. M. Murphy, Final Report 61-1 Contract Nonr 1100(14) March 1961.
 "An Investigation of the Mean Liquid Film Thickness and the Characteristics of the Interfacial Surface in Annular, Two-Phase Flow," by D. Charvonia, ASME Preprint 61-WA-243, Nov. 1961.

PURDUE UNIVERSITY, School of Mechanical Engineering.

(3812) TURBULENCE CHARACTERISTICS OF FLOW ALONG A CORNER.

- (b) Laboratory project.
- (c) Dr. J. B. Jones, Professor of Mech. Engrg., Purdue Univ., Lafayette, Indiana.
- (d) Experimental basic research for a doctoral thesis.
- (e) The investigation is concerned with the phenomenon known as secondary flow for steady, incompressible, turbulent flow along a corner. Since the problem is concerned with three-dimensional boundary layer flow, an analytic approach is not feasible. The research will consist of constructing a flow model to explain the nature of the secondary flow and then to verify the model by taking velocity and turbulence measurements. It is hoped that by examining the turbulence structure of a developing turbulent boundary layer, some explanation might be deduced regarding the growth and driving mechanism of the secondary flow.
- (g) Results to date verify Prandtl's hypothesis regarding directional turbulence characteristics along curved isotachs in the vicinity of the corner bisector.
- (h) "A Preliminary Study of Turbulence Characteristics of Flow Along a Corner," by F. B. Gessner and J. B. Jones - to be published in the Journal of Basic Engineering.

(3814) BOUNDARY LAYER MEASUREMENTS USING TRANSVERSE CYLINDRICAL PITOT PROBES.

- (b) Laboratory project.
- (c) Dr. J. B. Jones, Prof. of Mechanical Engineering, Purdue University, Lafayette, Indiana.
- (d) Experimental; for Master's thesis.
- (e) The purpose of the study was to determine error involved in using transverse cylindrical total pressure probes to measure incompressible boundary layer profiles. A method utilizing the location of the point of minimum dynamic pressure to establish correct velocity profiles was developed.
- (f) Completed.

(4193) FLOW IN A PIPE FOLLOWING AN ABRUPT INCREASE IN SURFACE ROUGHNESS.

- (b) Laboratory project.
- (c) Dr. J. B. Jones, Prof. of Mechanical Engrg., Purdue University, Lafayette, Indiana.
- (d) Experimental basic research for doctoral thesis.
- (e) Measurements of velocity, turbulence intensity, and Reynolds stress distributions following a sudden increase in surface roughness of a pipe are reported. The wall shear stress increases abruptly to its final value and the pressure gradient is very nearly constant throughout the transition region. Reynolds stresses throughout much of the transition region reach values exceeding those in fully-developed flow in the rough pipe. The need for knowledge of shear stress distributions for use in the calculation of velocity distributions is pointed out. A flow model is suggested.
- (f) Completed.
- (g) Paper submitted to ASME.

(4194) TURBULENT FLOW IN THE INLET REGION OF A

SMOOTH PIPE.

- (b) Laboratory project.
- (c) Dr. J. B. Jones, Prof. of Mechanical Engrg., Purdue University, Lafayette, Indiana.
- (d) Experimental basic research for doctoral thesis.
- (e) This work reports measurements of mean velocities, turbulence (Reynolds) stresses in the inlet region of a smooth pipe. Data are presented for the first forty diameters of pipe length. Fully-developed flow is not attained in this length for a Reynolds number (based on pipe diameter and mean velocity) of 388,000, but the wall shear stress and the static pressure gradient attain their fully-developed values within the first fifteen diameters. Velocity profiles at successive sections in the inlet region are not similar as assumed in some published calculation methods. Longitudinal convection of turbulence energy is appreciable; except very near the pipe entrance, radial convection is negligible.
- (f) Completed.
- (g) Paper submitted to ASME.

(4195) A STUDY OF WAVE PHENOMENA IN A SMALL SHOCK TUBE.

- (b) Laboratory project.
- (c) Dr. E. J. Wellman, Associate Prof. of Mechanical Engineering, Purdue University, Lafayette, Indiana.
- (d) Experimental and analytical research for master's thesis.
- (e) The performance of a small shock tube constructed for instructional purposes is being analyzed under various operating conditions. Optimum values of the parameters which may be readily adjusted are being sought. In the experimental work two pressure transducers are being used to measure pressures and determine wave velocities.

(4196) INCOMPRESSIBLE FLOW OVER A FORWARD FACING STEP.

- (b) Engineering Experiment Station, Purdue University.
- (c) Dr. R. W. Fox, Asst. Prof. of Mech. Engrg., Purdue Univ., Lafayette, Indiana.
- (d) Experimental basic research for master's thesis.
- (e) The purpose of this investigation is to gain additional information on the flow over a forward facing step. The specific aspects of this problem being considered are: (1) The variation of the wall static pressure preceding, following, and along the face of the step; (2) the flow pattern (streamline pattern and the shape of the separation region) over the step; (3) the shape of the velocity profile as separation is approached; and (4) the drag coefficient of the step. Step heights of 1, 3 and 6 inches, in a channel 16 inches in width, are being investigated for various free-stream velocities.
- (g) Previous investigation with step heights of 0.25 and 0.50 inches showed that: (1) The wall static pressure coefficient was a function of distance from the step and step height and was independent of the free-stream velocity and upstream boundary-layer thickness over the range of

$$1.2 \times 10^4 \leq \frac{U_1 \delta_1}{\nu} \leq 5.7 \times 10^4;$$

and (2) the drag coefficient was a fairly strong function of the ratio of step height to boundary-layer displacement thickness and a weak function of boundary-layer Reynolds number.

- (h) "Boundary Layer Flow Over a Forward Facing Step," by William J. Rivers III, Master's Thesis, January, 1961 (available on loan).

PURDUE UNIVERSITY, Automatic Control Laboratory,
School of Mechanical Engineering.

(4197) DYNAMIC RESPONSE OF HYDRAULIC LINES.

- (b) National Aeronautics and Space Administration
- (c) Dr. Rufus Oldenburger, School of Mechanical Engineering, Purdue University, Lafayette, Indiana.
- (d) Experimental and theoretical; basic research for masters and doctors theses.
- (e) The work on hydraulic lines is being done to establish simple mathematical relations for describing hydraulic phenomena associated with flow of liquids in pipes. The usual partial differential equations of flow through pipes are replaced by ordinary differential equations involving hyperbolic operators. These operators are replaced by simple, yet accurate, algebraic approximations. Frequency response runs are being made to check the validity of these approximations. The theory is being extended to flow through bends. Previous experimental work on the subject was done by Oldenburger and associates at the Appalachia Power House of the Tennessee Valley Authority and by John Sanders and associates at the Lewis Research Center of the NASA.
- (h) "Results for Flow in Cylindrical Pipes," by R. E. Goodson and R. Oldenburger, submitted for publication.

ROCKY MOUNTAIN HYDRAULIC LABORATORY.

(3496) TESTS OF RIPRAP SCOUR PROTECTION.

- (b) Standard Oil Company of Texas.
- (c) Prof. C. J. Posey, Rocky Mountain Hydr. Lab., Allenspark, Colorado.
- (d) Experimental; design development.
- (e) Protection of offshore structures.
- (f) Completed.
- (g) Model-prototype similitude for unusual type of erosion achieved by the use of Gilsonite.
- (h) "Erosion Protection of Production Structures," by C. J. Posey and J. H. Sybert, Ninth Convention, International Association for Hydraulic Research, Dubrovnik, 1961.

(4198) TESTS OF EROSION-PROOFING FOR CHUTES.

- (b) Laboratory Project.
- (c) Prof. C. J. Posey, Rocky Mountain Hydr. Lab., Allenspark, Colorado.
- (d) Experimental; design development.
- (e) To find reliable low-cost erosion protection for steep channels in erodible materials.
- (f) Active experimentation during summers.
- (g) Sixteen-mm film shows results of preliminary experiments.

ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA.

Inquiries concerning Projects 2144, 2603, 3153, 3156, 3161, 3164, 3497, 3499, 3502, 3503, 3504, 3819, 3820, 3821, 3822, 3824, 4199 to 4206, inclusive and 4208 to 4211 inclusive should be addressed to Dr. Lorenz G. Straub, Director, St. Anthony Falls Hydraulic Lab., Mississippi River at Third Avenue S.E., Minneapolis 14, Minnesota.

Inquiries concerning Projects 111, 1168, and 2386, which are conducted in cooperation with the Agricultural Research Service, should be addressed to Mr. Fred W. Blaisdell, Hydraulic Engineer, Soil and Water Conservation Research Division, Agricultural Research Service, St. Anthony Falls Hydraulic Lab., Minneapolis 14, Minnesota.

Inquiries concerning Project No. 194, which is conducted in cooperation with the Corps of Engineers and the U. S. Geological Survey, should be addressed to Engineer in Charge, Mr. Byron Colby, Federal

Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue, Minneapolis 14, Minnesota.

(111) CLOSED CONDUIT SPILLWAY.

- (b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Expt. Station and the St. Anthony Falls Hydraulic Laboratory.
- (d) Experimental; generalized applied research for development and design.
- (e) A two-sided drop inlet having a width equal to the pipe diameter and a variable length is currently being tested. The anti-vortex device consists of a horizontal plate supported above the crest of the drop inlet by end piers. The characteristics, performance, losses, and pressures in the drop inlet and on the anti-vortex plate are being determined for various combinations of drop inlet length, and height and overhang of the anti-vortex plate. Water is used as the model fluid to determine the performance characteristics, and head-discharge relationships during flows of water-air mixtures. For full flow, air is used as the model fluid to determine the various energy loss coefficients and the pressure coefficients.
- (g) The theory of closed conduit spillways has been developed, verified, and published. Results of tests on many forms of the closed conduit spillway entrance have been published. Pipe culverts laid on steep slopes may flow completely full even though the outlet discharges freely. Generalized methods for analysis and reporting of the results have been developed. The use of air as the model fluid has been verified by comparing test results with those obtained using water as the model fluid. The drop inlet with the horizontal anti-vortex device causes the spillway to act as a self-regulating siphon when the headpool level approximates the anti-vortex plate elevation. The height of the anti-vortex plate above the drop inlet crest and the overhang of the anti-vortex plate determine the effectiveness of the plate as an anti-vortex device.

(1168) A STUDY OF CANTILEVERED OUTLETS.

- (b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Expt. Station and the St. Anthony Falls Hydraulic Laboratory.
- (d) Experimental; generalized applied research for design.
- (e) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts will be made to determine quantitatively the size of the scour hole to be expected under various field conditions.
- (f) Suspended.

(1929) DRAIN TILE JUNCTION LOSSES.

- (b) Minnesota Agricultural Expt. Station in cooperation with the Agricultural Research Service, U. S. Dept. of Agriculture and the St. Anthony Falls Hydraulic Laboratory.
- (c) Prof. Philip W. Manson, University of Minnesota, St. Paul Campus, St. Paul, Minn.
- (d) Experimental; generalized applied research for design.
- (e) The junction losses in drain tile flowing full are determined for laterals of different sizes entering mains of different sizes at various angles. Additional tests have been made with the crowns (or inverts) of both main and lateral in the same plane.
- (f) Completed.
- (g) Tests have been completed on sharp edge junctions entering the main at angles varying in 15 degree increments from 15 degrees to 165 degrees. Both the lateral and the main are completely full. The tests

- cover all possible combinations of discharge in the lateral and in the main. Laterals having areas $1/1$, $1/2$, $1/4$, $1/7$, and $1/16$ that of the main have been tested. A color motion picture film entitled "Energy Losses at Converging Pipe Junctions" has been completed and is available. The 16 mm film is 800 feet long.
- (h) "Loss of Energy at Sharp-Edged Pipe Junctions" by Fred W. Blaisdell and Philip W. Manson. Submitted for publication.
- (2386) GENERALIZED DESIGN OF TRANSITIONS FOR SUPERCRITICAL VELOCITIES.
- (b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Lab.
- (d) Experimental; generalized applied research for development and design.
- (e) Studies will be made to develop a transition and to determine the rules for its design. The transition will be used to change the flow cross section from circular to rectangular when the velocities are supercritical.
- (f) Suspended.
- (2144) EXPERIMENTAL AND ANALYTICAL STUDIES OF HYDROFOILS.
- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and analytical; basic research.
- (e) Investigation of the force characteristics and the air entrainment rates of an artificially ventilated hydrofoil of finite span in the vicinity of a free surface.
- (g) A semi-empirical expression has been derived to satisfactorily predict the air entrainment rates for artificially ventilated cavities in the reentrant jet region. The air entrainment was found to depend on velocity, drag coefficient, cavitation number based on vapor pressure, cavitation pressure, and aspect ratio. The presence of the free surface had little effect on lift and drag forces, and experimental values agreed roughly with available theory. Cavity characteristics were appreciably influenced by the free surface and tip effects of the finite span foils.
- (h) "Experimental Studies of Artificial Cavities on Submerged Hydrofoils of Finite Span," by J. M. Wetzel and F. R. Schiebe, Univ. of Minn., St. Anthony Falls Hydraulic Lab. Memo No. M-89, Minneapolis, Minnesota, Nov., 1960.
- "Ventilated Cavities on Submerged Hydrofoils of Finite Span," by F. R. Schiebe and J. M. Wetzel, Univ. of Minn., St. Anthony Falls Hydraulic Laboratory Memo No. M-91, Minneapolis, Minn., July 1961.
- (2603) WATER TUNNEL AIR CONTENT STUDIES.
- (b) David Taylor Model Basin, Dept. of the Navy.
- (d) Analytical and experimental applied research.
- (e) Establishment of procedures for acoustically measuring the size and number of small gas bubbles existing in water.
- (f) Reactivated.
- (g) Refinements underway on previous pilot studies.
- (3153) FLOW ABOUT BODIES AT SMALL CAVITATION NUMBERS.
- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and analytical; basic research.
- (e) The major interest is now in unsteady supercavitating flow. Both material and ventilated cavitation is under study. Unsteady flows of various types are under study experimentally in the free-jet water tunnel: (1) Variation of cavity pressure by adding air at variable rate; (2) variation of body angle of attack; (3) variation of free-stream velocity; and (4) variation of ambient pressure. Theoretical work on unsteady flows of symmetrical bodies is also underway.
- (g) For results of recently completed work on ventilated cavities and cavity noise, see the publications listed below. The current work indicates that for many purposes the unsteady effect is almost negligible; that is, the cavitation number-cavity length-cavity drag relation is nearly the same as for steady flow.
- (h) "Pulsation of Ventilated Cavities," by C. S. Song, St. Anthony Falls Hydraulic Laboratory Tech. Paper No. 32, Series B, February 1961.
- "Experimental Studies of Cavitation Noise in a Free-Jet Tunnel," by C. S. Song, and E. Silberman, St. Anthony Falls Hydraulic Laboratory, Tech. Paper No. 33, Series B, July 1961.
- (3156) WANAPUM SPILLWAY STUDIES.
- (b) Harza Engineering Company, Chicago; Public Utility District of Grant County, Ephrata, Washington.
- (d) Experimental; design and operation.
- (e) A 1:144 scale partial comprehensive model for Wanapum Power Project on Columbia River to arrive at optimum alignment of the earth fill dam and optimum exterior geometry for fish passing facilities.
- (f) Completed.
- (g) Satisfactory geometry for the fish passing facilities arrived at and riprap protection sufficient to protect against scour was determined.
- (3161) HYDRAULICS OF SEWER DROPSHAFTS.
- (b) City of St. Paul, Minnesota.
- (d) Experimental; applied.
- (e) Investigate relative merits of sewer drop structures for discharges up to 1000 cfs and drops up to about 100 feet.
- (f) Completed.
- (g) Impact type energy dissipator developed to stabilize flow and eliminate air from lower interceptor line.
- (3164) SCOUR AROUND BRIDGE PIERS.
- (b) Laboratory project.
- (d) Experimental and analytical; Ph.D. thesis.
- (e) Prediction and measurements of ultimate depths of scour around known shape and size of pier.
- (3497) WANAPUM FISH FACILITIES STUDIES.
- (b) Harza Engineering Company, Chicago; Public Utility District of Grant County, Ephrata, Washington.
- (d) Experimental; design and operation.
- (e) Two 1:36 scale models of right bank attraction water flow system and orifice and weir fish entrances for design verification and comparison of effectiveness of orifice versus weir entrances.
- (f) Completed.
- (3499) STUDIES OF HYDROFOIL CONFIGURATIONS IN REGULAR WAVES.
- (b) David Taylor Model Basin, Department of the Navy.
- (d) Experimental.
- (e) Experimental investigation of the longitudinal motions (heave and pitch) of various hydrofoil configurations for regular head and following seas to verify existing linear and non-linear theory.
- (g) In general, satisfactory agreement has been obtained between theory and experiment for tandem hydrofoil configurations utilizing combinations of dihedral and flat foils. For small wave amplitudes, linearized theory

- proved to be adequate. Non-linear theory indicated a steady-downward component of heave and pitch that was of considerable magnitude in following seas. Experimental measurement for these components were in general greater than predicted by theory.
- (h) "Experimental and Analytical Studies of the Longitudinal Motions of a Tandem Dihedral Hydrofoil Craft in Regular Waves," by J. M. Wetzel, St. Anthony Falls Hydraulic Lab. Technical Paper No. 30, Series B, April 1960.
- (3502) MANGLA SPILLWAY STUDIES.
- (b) Harza Engineering Company, Chicago; Binnie, Deacon, and Gourley, London; Government of Pakistan.
- (d) Experimental; design and operation.
- (e) Two 1:300 scale models of two stage stilling basin energy dissipator. A comprehensive model and a section model consisting of half the control structure and basin for study of all important hydraulic features. A 1:108 scale section model consisting of two control structure gates, a study of pressures on gate and gate calibration. Typical dimensions of earth fill dam spillway include a drop in water level of 330 feet and a design discharge of 1,100,000 cfs.
- (3503) ARKANSAS RIVER DEVELOPMENT SEDIMENT STUDIES.
- (b) U. S. Army Engineer District, Little Rock.
- (d) Experimental; design.
- (e) To investigate the feasibility of constructing an armor layer on the bed of a stream to stabilize the bed and prevent degradation.
- (f) Completed.
- (g) Results suggest that the armor material will stabilize the bed under certain conditions.
- (3504) EXPERIMENTAL DETERMINATION OF UNSTEADY LIFT AND DRAG FORCES ON DIHEDRAL HYDROFOILS IN WAVES.
- (b) David Taylor Model Basin, Department of the Navy.
- (d) Experimental; basic research.
- (e) General investigation of the forces on dihedral, surface-piercing hydrofoils in regular waves. A study was also made of the forces on a hydrofoil placed in the wake of another, as would be the case of a tandem configuration.
- (f) Completed.
- (g) Lift and drag measurements were made on a restrained surface-piercing dihedral hydrofoil in regular head and following seas. The oscillatory lift was predicted with fair success using linearized theory. The experimental forces were observed to contain harmonic distortion, and comparison of the second harmonic component obtained from non-linear quasi-steady theory indicated that the calculated values were too low. Tests with a restrained tandem dihedral configuration in smooth water indicated that the performance rates of the aft foil could be considerably increased for a particular separation of the foils. The optimum separation increased with increasing velocity.
- (h) "Lift and Drag of Surface-Piercing Dihedral Hydrofoils in Regular Waves," by J. M. Wetzel and F. R. Schiebe, University of Minnesota, St. Anthony Falls Hydraulic Lab., Project Report No. 64, September 1960.
- (3619) DESIGN STUDIES FOR SOUTH SASKATCHEWAN RIVER PROJECT.
- (b) Canada Department of Agriculture, Prairie Farm Rehabilitation Administration, Regina, Saskatchewan.
- (d) Experimental; applied research.
- (e) Experimental studies of the preliminary design of components of the diversion tunnel system and spillway system of South Saskatchewan River Project.
- (g) Tests of the diversion system showed good agreement between computed and measured head-discharge curves. Other tests indicated that the design of all aspects of the diversion and spillway system were sound, but that some saving could be effected in the design of the temporary tunnel stilling basins.
- (3820) MODEL STUDIES OF CHUTE NO. 2 AT ST. ANTHONY FALLS.
- (b) Northern States Power Company, Minneapolis.
- (d) Experimental; applied.
- (e) Experimental study of various methods for reduction of bed scour below existing Chute No. 2.
- (f) Completed.
- (g) A stilling basin of the SAF type was developed and tested; erosion was materially reduced. An alternate design which was tested and which indicated acceptable scour characteristics consisted of a horizontal section of chute located at the water surface; this structure was fitted with terminal blocks similar to conventional stilling basins.
- (3821) STRUT INTERFERENCE EFFECT ON HYDROFOIL SYSTEMS.
- (b) Office of Naval Research, Bureau of Ships, Department of the Navy.
- (d) Experimental; applied research.
- (e) Investigation of the interference effects of supporting struts on the lift drag of typical hydrofoil configurations.
- (f) Completed.
- (g) Pressure distribution measurements made in a towing tank were used to evaluate lift and drag near junctions. Selected models under a variety of conditions were tested.
- (h) "Interference Effects of a Strut on the Lift and Drag of a Hydrofoil" by John F. Ripken, St. Anthony Falls Hydraulic Lab., Univ. of Minn., Project Report No. 65, August 1961.
- (3822) FLOW OVER VIBRATING PLATES.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Experimental; applied research.
- (e) Studies on a water tunnel with one wall externally excited into forced vibration to determine the effect of wall vibration on the boundary layer.
- (3824) SURFACE CHARACTERISTICS OF AIR ENTRAINMENT FLOW IN STEEP CHANNELS.
- (b) Laboratory project.
- (d) Analytical and experimental investigation of the air concentration, velocity distribution, and surface roughness of water flow in steep open channels, Ph.D. thesis.
- (e) Experimental investigation was carried out on the SAF high velocity channel for slopes up to 53 degrees. Velocities were measured by means of a pitot tube on high speed photography. Air concentration was measured by the SAF concentration meter. The surface elevation was measured by a device which measures the average time the surface is above a given elevation.
- (f) Experimental work completed.
- (4199) GEOMETRY OF AIR CAVITIES IN A BOUNDARY LAYER.
- (b) David Taylor Model Basin, Dept. of the Navy.
- (d) Experimental; basic research.
- (e) Experiments will be performed to observe the geometry of the air cavity formed downstream of wedges attached to the boundary. Air will be introduced through ports on the downstream edge of the wedge and the geometry of the cavity and air demand will be observed in relation to wedge length and thickness. The objective is to examine reduction of drag due to presence of air in the boundary

layer.

- (4200) INVESTIGATION OF THE FORCES AND INTERFERENCE EFFECT OF TANDEM FLAT HYDROFOILS.
- (b) Office of Naval Research, Dept. of the Navy.
 - (d) Experimental basic research.
 - (e) Investigation of the lift and drag forces on the aft foil of a tandem hydrofoil configuration to determine the effect of the downwash and wave pattern from the forward foil.
 - (g) Results not yet available.
- (4201) GURI HYDROELECTRIC PROJECT MODEL STUDIES.
- (b) Harza Engineering Company, Chicago, Corp. Venezolano de Guayana.
 - (d) Experimental, design and operation.
 - (e) Preliminary study for the design of the Guri Hydroelectric development on the Caroni River, Venezuela using a 1:394 comprehensive model and a 1:197 spillway section model.
- (4202) MICRO BUBBLE STUDIES.
- (b) David Taylor Model Basin, Dept. of the Navy.
 - (d) Analytical and experimental applied research.
 - (e) Measurement of micro bubble structure of laboratory and natural waters to determine ambient bubble conditions before and after exposure of water to dynamic disturbances.
- (4203) HYDRAULIC DESIGN OF AN OVERFALL FOUNDED ON PERMEABLE SOILS.
- (b) Laboratory project.
 - (d) Theoretical and experimental, for Ph.D. thesis.
 - (e) Stability of the hydraulic overfall founded on limited depth of permeable soils, under the influence of infiltrating flow underneath the structure, and also in the presence of adverse surface flow conditions was studied. Magnitude and direction of the exit velocity is taken as the criteria for determining the stability. Experimental work necessary to support theoretical results was also conducted.
 - (g) By employing the Schwartz-Christoffel transformation the influence of the infiltrating flow in causing uplift pressures on the base of the structure and also the exit velocity pattern at the downstream bed level was studied. Assuming the surface flow, immediately downstream of the overfall as causing a standing wave, the additional effect of this flow on the exit velocity pattern was evaluated. Experimental data were also obtained confirming the theoretical solution of the problem.
- (4204) PRESSURE DISTRIBUTION UNDER HYDRAULIC STRUCTURES ON PERMEABLE FOUNDATIONS.
- (b) Project conducted for thesis study for the degree of Master of Science.
 - (d) Experimental research.
 - (e) The variations in pressure distribution under structures on permeable foundations and subject to a hydraulic head with different thicknesses of the permeable medium and the geometry of the boundary of the medium, were studied on electrical analogy.
 - (f) Complete.
- (4205) STUDY OF SEEPAGE INTO SUB-SURFACE DRAINS BY THE HYDRAULIC AND ELECTRIC ANALOG METHODS.
- (b) Laboratory project.
 - (d) Experimental; master's thesis.
 - (e) To investigate use of hydraulic analog for study of seepage to sub-surface drains and compare results obtained by hydraulic and electric analogs.
 - (f) Completed.
 - (h) "Study of Seepage Into Sub-Surface Drains by the Hydraulic and Electric Analog Methods," by Warren Q. Dahlin, Master's thesis, 1961,
- on file at the University of Minn. library.
- (4206) AN EXPERIMENTAL INVESTIGATION OF THE VARIATION OF VELOCITY DISTRIBUTION WITH TIME IN A DECAYING VORTEX.
- (b) M. Sc. thesis study.
- (4207) A STUDY OF THE INFLUENCE OF ENTRAINED GAS NUCLEI ON THE CAVITATION NOISE SPECTRUM IN A SIX INCH WATER TUNNEL.
- (b) Laboratory project.
 - (c) Mr. F. R. Schiebe, Associate Scientist, St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota.
 - (d) Experimental, basic research, Master's thesis.
 - (e) In this study the noise spectrum of cavitation is being studied close to incipient conditions. The free air content of the tunnel water is varied through the range two parts per million to 200 parts per million by volume and the effect noted on sound spectrum taken by hydrophones mounted in the immediate vicinity of the cavitation and on the tunnel wall.
 - (g) Significant differences in the sound spectrums are noted as the air content of the water is increased.
- (4208) INVESTIGATION OF THE PROPERTIES OF SEDIMENT WAVES IN OPEN CHANNELS.
- (d) Experimental and theoretical; basic research.
 - (e) To investigate the formation of sediment ripples and dunes in open channels, with particular reference to the relation between the sediment waves physical characteristics, those of the bed material and of fluid flow. Relation between sediment wave length and flow properties analyzed theoretically and confirmed using published experimental data.
 - (f)
- (4209) THE INFLUENCE OF ELECTROKINETIC PHENOMENA ON THE HYDRAULIC AND ELECTROOSMOTIC PERMEABILITY OF UNIFORM VERY FINE SANDS.
- (b) Laboratory project.
 - (d) Experimental and theoretical; Ph.D. thesis.
 - (e) Accurately sized, narrow range, angular quartz particles and spherical glass beads were tightly placed in a permeameter with reversible silver-silver chloride electrodes at the ends of the test section. Streaming potential, streaming current, electrical resistivity of low conductivity liquid, and filter velocity were precisely measured. Studies include: (1) Flow retardation from return electroosmosis; (2) analysis of electroosmotic permeability factors with respect to particle characteristics and hydraulic permeability, and (3) comparisons of streaming current and filter velocity at varying Reynolds numbers.
 - (g) It has been found that the streaming current-potential varies linearly with hydraulic gradient to a slightly higher Reynolds number than the filter velocity. Lack of complete deaeration causes a larger reduction in the filter velocity than the streaming. When "boiling" action takes place anomalous relations between the filter velocity and streaming current occur.
- (4210) HYDRAULIC CHARACTERISTICS OF A FREE OVERFALL SPILLWAY.
- (b) Laboratory project.
 - (d) Theoretical and experimental for Master's Thesis.
 - (e) The longitudinal and vertical pressure distribution and surface profile was calculated for bucket type spillways. Experiments were performed on a similar spillway to verify the calculations and to study departure from the theoretical. Comparisons were made with existing prototype spillways.

- (f) Completed.
 - (g) Experiments show good agreement with the calculations and supply data for pressure distribution and water surface profiles.
 - (h) "Hydraulic Characteristics of a Free Overfall Spillway," by Antonio L. Rosquette, a thesis submitted to the Faculty of the University of Minnesota in partial fulfillment of the requirements of a MS(CE) degree.
- (4211) THE CRITICAL SHEAR STRESS IN ALLUVIAL WATERCOURSES.
- (b) Laboratory project.
 - (d) Analytical for Ph.D. thesis.
 - (e) Critical shear stress is defined as the shear stress at the bed when a given probability exists that the equilibrium of soil particles of the bed will be upset. An equation for particle equilibrium depending on the lift/shear stress ratio is written and solved for certain conditions. Writing the equilibrium equation involved a rather extensive secondary investigation of velocity distribution near a rough bed; the Karman-Prandtl law proved inadequate for this purpose.
 - (f) Completed.
 - (g) A formula for critical shear stress in clear water flow over a horizontal bed is presented. This involves the buoyant specific weight of the bed particles, the angle of repose of the material, the effective grain size of the particles and the equivalent sand grain roughness size. The effect of other factors such as the presence of ripples, longitudinal and transverse curvature, and suspended sediment on the formula is also presented.
 - (h) "A Treatise on the Critical Shear in Alluvial Watercourses," by Bent A. Christensen, a thesis submitted to the faculty of the University of Minnesota in partial fulfillment of the requirements for the Ph.D. degree.

INTER-AGENCY SEDIMENTATION PROJECT IN COOPERATION WITH ST. ANTHONY FALLS HYDRAULIC LABORATORY.

- (194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.
 - (b) Subcommittee on Sedimentation, Inter-Agency Committee on Water Resources, Personnel of the U. S. Army Corps of Engineers and the U. S. Geological Survey are actively engaged on the project.
 - (c) Engineer in Charge, Mr. Byron C. Colby, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Hennepin Island and Third Avenue S. E., Minneapolis 14, Minnesota.
 - (d) Experimental; applied research and development.
 - (e) Drawings and specifications are available to facilitate the manufacture of suspended-sediment and bed-material samplers, particle-size analyzers and associated laboratory equipment. Approved designs for the measurement of suspended sediment include a single-stage sampler, 4-, 22- and 62-pound samplers, and electrically-operated samplers weighing 100 and 300 pounds. For the measurement of bed material there are a piston type hand-operated sampler, a 30-pound hand-line sampler, and a 100-pound sampler for cable suspension. Additional apparatus include a sediment sample splitter, a bottom-withdrawal sedimentation tube for size analyses, and a visual-accumulation sedimentation tube with recording equipment for particle size analyses of sands. The primary objective of the current program is the development of an instrument to automatically record suspended-sediment concentrations in flowing streams. Tests have been conducted on intermittent pumping type samplers, turbidimeters, and electronic, ultrasonic, nuclear and pressure sensing devices.
- (g) Report No. 13, "The Single-Stage Sampler for Suspended Sediment" is in the final stages of reproduction by the Government Printing Office. Tests on pumping type samplers are being expanded by cooperating agencies. The sediment wheel recording device was transferred to the Agricultural Research Installation near Oxford, Miss., for intermittent operation on an ephemeral type stream. An experimental model of a bottle wheel sampler was installed by the U. S. Geological Survey at Bixler Run, near Loysville, Pennsylvania. A progress report is being prepared on three types of intermittent pumping samplers. The nuclear sediment density probe was modified and improved by the Soil and Water Conservation Research Division of the Agricultural Research Service at Beltsville, Md., and the probe was calibrated by the Sedimentation Laboratory of the Agricultural Research Service at University, Mississippi. Under certain conditions a turbidity meter utilizing the diffusion of light as a measure of solids in suspension can be calibrated to determine both sediment concentration and the size distribution of sediment finer than 100 microns. Appropriate test procedures and methods of computation are being investigated. Exploratory and calibration tests on the electronic sensing instrument are yielding results consistent with those obtained by microscopic procedures. The ultrasonic device has been modified. A report titled "Ultrasonic Measurement of Size Distribution and Concentration of Suspended Sediments" by Gordon Flammer is scheduled for publication by the U. S. Geological Survey under "Contributions to General Geology, 1961, No. 1141."
- (h) "Investigations of Differential Pressure Gages for Measuring Suspended-Sediment Concentrations," Report P, 46 pages, June 1961.
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- SCRIPPS INSTITUTION OF OCEANOGRAPHY, University of California.
- (3825) GENERATION AND PROPAGATION OF INTERNAL WAVES.
 - (b) Laboratory project.
 - (c) Dr. Charles Cox, Scripps Institution of Oceanography, La Jolla, California.
 - (d) Experimental and theoretical basic research.
 - (e) Observations of temperature fluctuations as functions of depth from surface to bottom of the sea are made at an array of automatically recording stations. Analysis in terms of internal waves of various modes within a spectrum of frequencies at each station permits estimation of pattern of radiation of internal waves. Theoretical studies suggest the importance of conversion of tidal energy into internal motions by interaction with a rough sea bottom. Experimental investigation of this process will permit estimation of the flow of energy between wave modes and its ultimate fate.
 - (g) Theoretical results suggest that a moderate fraction of tidal energy can be converted into internal motions in one tidal cycle.
- (4212) DIRECTIONAL RECORDING OF OCEAN WAVES.
- (b) IGY and post-IGY.
 - (c) Dr. Walter H. Munk, Scripps Inst. of Oceanography, La Jolla, California.
 - (d) This is a combined theoretical and field investigation, to be classified as basic research.
 - (e) The use of array methods to obtain the directional frequency spectra of ocean swell.
 - (f) Completed.
 - (g) The time, distance, and direction of distant

storms has been estimated from the analyses of wave records obtained on an array of bottom pressure recorders.

- (h) Philosophical Transactions of the Royal Society, in press.

(4213) LONG-PERIOD WAVES OVER CALIFORNIA'S CONTINENTAL BORDERLAND.

- (b) Office of Naval Research Dept. of the Navy.
 (c) Dr. Walter H. Munk, Scripps Institute of Oceanography, La Jolla, Calif.
 (d) Theoretical and field investigation.
 (e) The recording of waves in the frequency transfer 0.2 to 60 cycles per hour.
 (f) Completed.
 (g) The background spectra indicate the presence of both free and trapped modes, with resonances associated with the dimensions of the continental shelf. The data of tsunamis in this frequency range indicate a damping time of 12 hours roughly independent of frequency.
 (h) Journal of Marine Research.

(4214) GENERAL STUDY OF LOW-FREQUENCY GRAVITY WAVES IN THE SEA.

- (b) Office of Naval Research and National Science Foundation.
 (c) Dr. W. G. Van Dorn, Scripps Institute of Oceanography, La Jolla, California.
 (d) Theoretical, laboratory and field studies of mechanisms of generation, propagation, and dissipation of low-frequency gravity waves, with special attention to impulsively generated waves, such as those produced by earthquakes and large explosions.
 (e) Project currently operates three long-period wave stations at Wake, Johnston, and Canton Islands. These stations continuously monitor surface waves in the range two minutes to four hours period, microbarometric air pressure in the same period range, wind speed and direction, and subsurface water temperature at depths of 600 and 800 feet. These records are analyzed for relationships existing between any of the above variables, and the presence of low-frequency waves from earthquakes and hurricanes. A laboratory study is currently being made of the runup and reflection characteristics of very low steepness waves from beaches of very small slope, with view to understanding the large wave enhancements observed for tsunamis, as well as the shift in spectral energy believed to occur upon reflection. This study will be carried out in a specially constructed plexiglas wave channel of about 100 ft. long, 2 ft. wide, and 6 in. deep. Long waves will be generated by slightly tipping any or all sections of the channel by cam rollers, and measuring the wave properties with sensitive pressure transducers beneath the channel.
 (g) It has been discovered that centered wave systems in the open sea, such as those resulting from earthquakes or large explosions are well described by linear theory if the variable depth of water is taken into account. This theory has then been used to compute the nature of the source motion of a tsunami in general agreement with independent evidence.
 (h) "Some Characteristics of Low Frequency Gravity Waves in the Sea Produced by Nuclear Explosions," by W. G. Van Dorn, Journal Geophysical Research, Vol. 66 No. 11, November 1961.
 "The Source Motion of the Tsunami of March 9, 1957, as Deduced From Wave Measurements at Wake Island," by W. G. Van Dorn, Annals of IUGG, in press.

SEWERS.

- (b) Laboratory project.
 (c) Prof. I. W. Santry, Jr., Prof. of Civil Engrg., Dept. of Civil Engrg., Southern Methodist Univ., Dallas 22, Texas.
 (d) Theoretical and experimental; applied research for undergraduate thesis.
 (e) The project will use a theoretical approach to the development of means of action occurring in open channel flow junctions from which measurement methods will be derived for evaluation by experimentation on models. The junction pipe will be varied in size with relationship to the main pipe from 1/4 to full size. The angles of the wye will be varied from 22-1/2 degrees to 90 degrees. Also, the position of the pipe crowns and hydraulic gradients will be varied as well as flow depths. It is hoped that the results will yield information which will be useful in design of prototypes.

SOUTHWEST RESEARCH INSTITUTE, Department of Mechanical Sciences.

(3826) HYDRODYNAMICS OF SHIP SLAMMING.

- (b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
 (c) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
 (d) Theoretical; applied research.
 (e) Study of pressure distribution on bodies of arbitrary cross-section entering a plane water surface.
 (h) "Hydrodynamic Theories of Ship Slamming - Review and Extension," by W. H. Chu and H. N. Abramson, Jour. of Ship Research, Vol. 4, No. 4, pp. 9-21, March 1961. Three additional Southwest Research Inst. technical reports.

(3828) STUDIES IN HYDROELASTICITY.

- (b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
 (c) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
 (d) Experimental, theoretical; applied research.
 (e) Present work includes the design, construction, and testing of flexible hydrofoil models to obtain data on unsteady hydrodynamic lift and moment for a variety of operating conditions.

(4216) STUDIES OF FUEL SLOSHING.

- (b) National Aeronautics and Space Administration, Marshall Space Flight Center.
 (c) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
 (d) Theoretical and experimental; applied research.
 (e) Studies of forces and moments in missile fuel tanks resulting from sloshing motions of fuel.
 (h) "Dynamic Loads Resulting From Fuel Motion in Missile Tanks," by Thomas B. Epperson, Robinson Brown and H. Norman Abramson, Advances in Ballistic Missile and Space Technology, 2, pp. 313-327, Pergamon Press, New York, 1961.
 "Sloshing of Liquids in Cylindrical Tanks of Elliptic Cross-Section," by Wen-Hwa Chu, ARS Journal, 30, pp. 360-363, April 1960.
 "Some Comparisons of Sloshing Behavior in Cylindrical Tanks with Flat and Conical Bottoms," by H. Norman Abramson and Guido E. Ransleben, Jr., ARS Journal, 31, pp. 542-544, April 1961.

SOUTHERN METHODIST UNIVERSITY, Hydraulics Laboratory.

(4215) CHARACTERISTICS OF WYE JUNCTIONS IN STORM

"A Note on Wall Pressure Distributions During Sloshing in Rigid Tanks," by H. Norman Abramson and Guido E. Ransleben, Jr., ARS Journal, 31, pp. 545-547, April 1961.

"Simulation of Fuel Sloshing Characteristics in Missile Tanks by Use of Small Models," by H. Norman Abramson and Guido E. Ransleben, Jr., ARS Journal, 30, pp. 603-612, July 1960.

"Representation of Fuel Sloshing in Cylindrical Tanks by an Equivalent Mechanical Model," by H. Norman Abramson, Wen-Hwa Chu and Guido E. Ransleben, Jr., ARS Journal, 31, November 1961.

"Free Surface Condition for Sloshing Results From Pitching and Some Corrections," by Wen-Hwa Chu, ARS Journal, 30, pp. 1093-1094, November 1960.

"Amazing Motions of Liquid Propellants," by H. Norman Abramson, Astronautics, 6, 3, pp. 35-37, March 1961.

"Liquid Dynamic Behavior in Rocket Propellant Tanks," by H. Norman Abramson, Proceedings of the Symposium on Structural Dynamics of High Speed Flight, Office of Naval Research, Washington, D. C., 1961.

(4217) LIQUID DYNAMIC BEHAVIOR IN ROCKET TANKS.

- (b) National Aeronautics and Space Administration, Washington, D. C.
- (c) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
- (d) Theoretical and experimental; applied research.
- (e) Studies of liquid dynamic behavior in elastic tanks.
- (h) "Discussion of Production of Rotation in a Confined Liquid Through Translational Motion of the Boundaries," by Guido E. Ransleben, Jr. and H. Norman Abramson, Journal of Applied Mechanics, 27, p. 365, June 1960.
- "Some Studies of Liquid Rotation and Vortexing in Rocket Propellant Tanks," by H. Norman Abramson, Wen-Hwa Chu, Luis R. Garza and Guido E. Ransleben, Jr., NASA Technical Note (1961).

(4218) LIQUID MOTION IN SPHERICAL TANKS.

- (b) Laboratory project.
- (c) Mr. Wen-Hwa Chu, Senior Research Engineer, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas.
- (d) Theoretical; applied research.
- (e) Analysis of liquid motion in spherical tank of arbitrary depth and development of equivalent mechanical analogy.

STANFORD UNIVERSITY, Department of Civil Engineering.

(1946) SYNTHESIS OF HYDROGRAPHS FOR SMALL AREAS.

- (b) National Science Foundation.
- (c) Prof. Ray K. Linsley, Dept. of Civil Engrg., Stanford University, Stanford, California.
- (d) Theoretical and field investigation; basic and applied research; Ph.D. thesis.
- (e) An attempt to develop a universal method for estimating the runoff hydrographs from small areas.
- (f) A simplified theory for non-equilibrium conditions has been compared with experimental results taken under controlled laboratory conditions. A statistical analysis of data from several typical basins has been started. A mathematical analysis of the non-equilibrium flow in a simple channel with lateral inflow has been completed. The later work is being extended to more complex conditions via digital computing methods. Statistical and computer methods are being explored to develop a basis for reliable estimates of runoff frequency.
- (h) "Computation of a Synthetic Streamflow

Record on a Digital Computer," by Ray K. Linsley and Norman H. Crawford, Publication No. 51, International Assoc. of Scientific Hydrology, pp. 526-538, 1960.

(2151) MODEL STUDY OF PETERS DAM CHUTE SPILLWAY.

- (b) Laboratory project.
- (c) Prof. John K. Vennard, Dept. of Civil Engrg., Stanford University.
- (d) Experimental; engineer thesis.
- (e) Comparison of spillway performance and design predictions.
- (g) Experimental work completed; thesis being written.

(2614) PIPE FRICTION IN UNSTEADY FLOW.

- (b) Laboratory project.
- (c) Prof. John K. Vennard, Dept. of Civil Engineering, Stanford University.
- (d) Experimental and analytical; Ph.D. thesis.
- (e) Comparison of friction processes for steady and unsteady states.
- (g) Experimental work completed and analyzed; thesis being written.

(2863) FLOW THROUGH POROUS MEDIA.

- (b) National Science Foundation.
- (c) Prof. Byrne Perry, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif.
- (d) Theoretical and experimental; basic research.
- (e) New analytical methods are being developed for unsteady seepage flow with a free surface, e.g., the seepage through an earth dam. The effect of non-rectilinear boundaries is also being considered.
- (g) Theoretical work in progress.
- (h) "Free Surface Flow in Homogeneous Porous Medium," J. Hydraulic Div., Proc. ASCE, Vol. 87, No. HY4, Part 1, July 1961, pp 181-220.
- "Boundary Effects on Seepage from Channels," by Hubert J. Morel-Seytoux, Tech. Rept. No. 7, Dept. of Civil Engineering, Stanford University, 1961.

(3166) HYDRODYNAMICS OF FLOW INTO CURB INLETS.

- (b) U. S. Bureau of Public Roads.
- (c) Prof. John K. Vennard and Prof. Byrne Perry, Dept. of Civil Engineering, Stanford Univ., Stanford, California.
- (d) Experimental and analytical; Ph.D. thesis.
- (e) A hydrodynamic theory has been developed for predicting the flow from a smooth, undepressed gutter into a curb opening inlet which intercepts 100% of the flow. Experimental confirmation is given.
- (f) Completed.
- (h) "Hydrodynamics of Flow into Curb-Opening Inlets," by Richard J. Wasley, J. Engg. Mechanics Div., Proc. ASCE, Vol. 87, No. EM 4, Part 1, Aug. 1961, pp 1-18.
- "Uniform Flow in a Shallow, Triangular Open Channel," J. Hydraulics Div., Proc. ASCE, Vol. 87, No. HY 5, September 1961, pp 149-170.

(3507) STUDY OF INFILTRATION.

- (b) U. S. Public Health Service.
- (c) Prof. Joseph B. Franzini, Dept. of Civil Engineering, Stanford University, Stanford, California.
- (d) Theoretical investigation; laboratory and field studies; basic research; Ph.D. theses.
- (e) An attempt is being made to develop relations between soil parameters and infiltration capacities. Investigation is being extended to unsteady unsaturated flow through soils as experienced in capillary rise, drainage, and infiltration situations.

(3508) EVAPORATION SUPPRESSION.

- (b) U. S. Public Health Service.
- (c) Prof. Joseph B. Franzini, Dept. of Civil

Engineering, Stanford University, Stanford, California.

- (d) Laboratory and field investigations.
- (e) Field studies with Class A evaporation pans have been employed to evaluate the evaporation reuction capabilities and biological attrition resistances of various monomolecular films. In a full scale program at a 40 acre lake methods of application of the film are being investigated together with the effect of the film on biota.
- (g) Full scale field tests using hexadecanol on a 40 acre lake during the summer of 1960 gave an evaporation reduction of 18 percent.
- (h) "Progress Report on Evaporation Suppression Research," by Joseph B. Franzini, WATER AND SEWAGE WORKS, Vol. 108, Part I, pp. 167-172, May 1961; Part II, pp. 221-225, June 1961.

(4219) SUPERCAVITATING HYDROFOIL THEORY.

- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Prof. Byrne Perry, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif.
- (d) Theoretical, basic research.
- (e) The forces on supercavitating hydrofoils having large curvature are being studied.

STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory.

(2154) INVESTIGATION OF SHIP MOTIONS AND HIGH SPEED SHIP FORMS.

- (b) ONR and BuShips, Dept. of the Navy.
- (c) Prof. Earl M. Uram, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical and experimental; basic research.
- (e) The development of a calculation method for predicting ship motions in a seaway. Investigation of hydrodynamic and motion characteristics of high speed ship forms for supercritical operation in search of considerable improvement of seakeeping qualities and powering requirements.
- (g) Parametric studies utilizing analog and digital computers of the stability, powering, and design characteristics of a semi-submerged craft similar in nature to a shallow-running submarine incorporating a surface piercing hydrofoil system to provide inherent heave, pitch and roll stability. Towing tank tests of a model of the craft are scheduled. An analytical study to determine the optimum drag configurations for such semi-submerged vehicles is also in progress. Calculations to determine ship motions in quartering seas are planned.

(2155) SEAKEEPING QUALITIES OF SHIPS AT ALL HEADINGS TO WAVES.

- (b) Bureau of Ships, Department of the Navy, (DTMB Technical Supervision).
- (c) Mr. P. G. Spens, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical and experimental; basic research.
- (e) To investigate the coupled responses of ship models at all headings to waves in order to assist in the prediction of sea-keeping qualities and to evaluate means of reducing or controlling ship motions so as to increase sea speeds. A self-propelled and rudder-controlled ship model is being tested at various headings to both regular and irregular long-crested waves. Coupled motion responses are being measured and parallel analytic studies are being made of equations of motion for ships with six degrees of freedom. Stability and control are also being studied.
- (g) Measurements have been made of wave-induced lateral forces and yawing moments on a Series 60 block 0.60 model in oblique waves.

(h) Report in preparation.

(2390) CONTROLLED FINS FOR REDUCING SHIP PITCHING.

- (b) Bureau of Ships, Department of the Navy (DTMB Technical Supervision).
- (c) Mr. P. G. Spens, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Experimental and analytical; applied research.
- (e) To determine the most desirable action of controllable fins at the bow or stern of a ship to reduce pitching in regular and irregular head seas.
- (f) Completed.
- (g) Model tests have been made with servo-controlled oscillating stern fins, with and without fixed bow fins, in regular and irregular waves. It appears that the reduction in extreme pitching motions in irregular waves is of the same order as the pitch reduction in regular waves. For a Mariner class ship, oscillating stern fins give a pitch reduction of 2 degrees (double amplitude) for an oscillating fin force of about plus or minus 250 tons.
- (h) Report in preparation.

(2393) MOTIONS AND BENDING MOMENTS OF SHIPS IN WAVES.

- (b) Bureau of Ships, Department of the Navy (DTMB Technical Supervision).
- (c) Mr. John Dalzell, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
- (d) Experimental and analytical; applied research.
- (e) Measurements of motions and external bending moments and shear of a jointed model of a high-speed naval vessel underway in irregular head waves of various degrees of severity in a towing tank. Results have been analyzed by cross-spectral techniques to determine frequency response functions, and are expected to indicate degree of applicability of superposition theory to ship response in extreme seas.

(2616) THE BLADE-FREQUENCY FORCE GENERATED BY A PROPELLER ON A BODY OF REVOLUTION.

- (b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
- (c) Dr. J. P. Breslin, Director, and Dr. S. Tsakonas, Head of Fluid Dynamic Division, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) The purpose is to evaluate the importance of the pulsating near field of the propeller in generating vibratory forces on ships and to determine the attenuation of these forces with tip clearance and number of blades. Case of axial propeller in water has been evaluated. Case of offset propeller near an infinitely long cylinder has also been analyzed.
- (h) Report in preparation.

(2865) EFFECT OF SPEED AND FULLNESS ON HULL BENDING MOMENTS IN WAVES.

- (b) American Bureau of Shipping.
- (c) Mr. John Dalzell, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, New Jersey.
- (d) Experimental; applied research.
- (e) To determine to what extent, if any, different longitudinal strength standards should be adopted for ships of different fullness and service speed. The hull midship bending moment of two models with block coefficients of 0.68 and 0.80 were measured in oblique regular seas.
- (f) Completed.
- (g) Over the range of fullness covered, only moderate differences in vertical and lateral midship bending moments were found. The

- observed differences did not consistently favor either end of the fullness range over the full design speed range.
- (h) "Effect of Fullness on Hull Bending Moments in Oblique Waves," by J. F. Dalzell and R. B. Zubaly, Davidson Laboratory Report 833, May 1961.
- (2866) AN ANALYTIC STUDY OF THE PRESSURE FIELD NEAR COUNTER-ROTATING PROPELLERS.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Dr. J. P. Breslin, Director, and Dr. S. Tsakonas, Head of Fluid Dynamics Division, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
- (d) Theoretical; applied research.
- (e) To compare the characteristics of counter-rotating propellers with those of a single propeller with regard to the magnitude of the oscillatory pressures produced at nearby points in the field. The study is divided into two parts. In the first, the pressure signal is calculated according to publication entitled "The Pressure Field Near a Ship Propeller," by J. P. Breslin, Jour. Ship Research, Vol. 1, No. 4, March 1958, by superposition of the individual propeller fields as though they were independent. In the second, an approximate treatment of the blade interaction is considered by the method given in "Aerodynamic Interference Between Moving Blade Rows," by Nelson Kemp and W. R. Sears, Jour. of Aer. Sc., Vol. 20, No. 9, September 1953.
- (f) Completed.
- (g) Expressions for the vibratory pressure field produced by the counter-rotating propeller system are developed in terms of the first and second blade harmonics of the individual propellers. It is found that the pressure signal due to counter-rotating propellers can be obtained from the summation of the pressure fields of the two components as though the two propellers operate as separate units, since their mutual interference has been found to contribute little to the total vibratory pressure signal in the near field. This study indicates that the counter-rotating propeller system has vibratory characteristics much superior to an equivalent single propeller having the number of blades of one of its components, delivering the same thrust at the same RPM of optimum conditions. The counter-rotating configuration, however, when operating in an acoustic field under open-water conditions, is noisier than the corresponding equivalent single propeller.
- (h) Davidson Laboratory Report No. 858, Sept. 1961.
- (3171) ANALYTICAL STUDY OF THE THRUST DEDUCTION OF A SINGLE-SCREW THIN SHIP.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Dr. S. Tsakonas, Head of Fluid Dynamics Division and W. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N.J.
- (d) Theoretical; applied research.
- (e) An analytical study for the evaluation of the potential part of thrust deduction for thin ships similar to Haskind's type, with varying coefficients of vertical and horizontal fullness, is undertaken in order to reveal the functional dependence on the geometry of the propeller-null configuration and propeller performance characteristics.
- (f) Completed.
- (g) Expressions have been evolved for the thrust deduction of a thin ship due to propeller and free surface effects when the center of the propeller is located (1) at the maximum submergence at the stern, and (2) at any arbitrary position. It has been found that while finning both sections and waterplane of conventional ships lowers the thrust deduction, the section coefficient is more effective than the waterplane coefficient. Furthermore axial displacement of the propeller is more effective in mitigating the drag augmentation than is vertical displacement. The free surface effect is an important contributor in most cases of practical interest. Furthermore the analysis strengthens the belief that the frictional part of the thrust deduction is of equal weight with the potential.
- (h) Davidson Laboratory Report No. 816, being published in the International Shipbuilding Progress.
- (3174) UNSTEADY LIFT AND MOMENT ON FULLY CAVITATING HYDROFOILS AT ZERO CAVITATION NUMBER.
- (b) Office of Naval Research, Department of the Navy.
- (c) Dr. M. Martin, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, New Jersey.
- (d) Theoretical; basic research.
- (e) Analytical studies of the forces and moments acting on a thin, supercavitating hydrofoil performing arbitrary oscillations is pursued on the basis of the acceleration potential method.
- (f) Completed.
- (g) Expressions for the lift and moment coefficients of a thin, super-cavitating plate performing arbitrary oscillations are developed in terms of the coefficients of a power series describing the chordwise amplitude distribution. General expressions are applied to the case of a foil moving through a stationary sinusoidal vertical gust and to that of a rigid foil performing heaving and rotational oscillations. Comparison is made with Sear's results for a fully wetted foil in a sinusoidal gust and Parkin's in the case of pure heaving motion. General conclusions as to the effect of the various parameters have been drawn.
- (h) Davidson Laboratory Report No. 821, March 1961.
- (3176) THEORY OF LATERAL MOTIONS OF SHIPS IN WAVES.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Dr. Pung Nien Hu, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson St., Hoboken, New Jersey.
- (d) Theoretical; basic research.
- (e) Analytical study of the lateral motions of surface ships with three degrees of freedom in oblique waves. The virtual mass, damping and dynamic coupling of a surface ship in oscillatory motion, as well as the hydrodynamic excitation forces and moments due to oblique waves have been evaluated. The free surface influence on the hydrodynamic forces have been included in the above. Further work on determining lateral ship motions is continuing.
- (g) "Lateral Force and Moment on Ships in Oblique Waves," DL Report 831, by Pung Nien Hu.
- (3509) THEORETICAL CALCULATIONS OF THE VIBRATORY THRUST PRODUCED BY A SHIP PROPELLER OPERATING IN THE WAKE OF A HULL.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Dr. S. Tsakonas, Head of Fluid Dynamics Div. and Winnifred R. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) Computational work is carried out to test the validity of the theory developed by

- Ritger and Breslin, "On the Quasi-steady and Unsteady Thrust and Torque of a Propeller in a Ship Wake". Comparison is made with the experimental results.
- (f) Completed.
 - (g) Comparison of results of the theoretical calculations with experimental results indicate that the unsteady flow theory underestimates considerably the model vibratory thrust and torque whereas the calculations based on the assumptions of quasi-steady flow agree within 8 to 10% with the expressions.
 - (h) Davidson Laboratory LR-827, February 1961.
- (3511) STUDIES OF THE SOUND PRESSURE FIELD GENERATED BY A MARINE PROPELLER OPERATING IN A WAKE.
- (b) United Aircraft Corporation, Research Dept.
 - (c) Dr. S. Tsakonas, Head of Fluid Dynamics Division, Dr. J. P. Breslin, Director of Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
 - (d) Theoretical; applied research.
 - (e) The sound pressure field of a rotating propeller in rectilinear motion is obtained by replacing the normal pressure distribution over the propeller by a distribution of acoustic pressure doublets acting at the propeller disc. The strength of this acoustic doublet distribution is obtained from unsteady aerodynamic theory in conjunction with Burrill's correction factors.
 - (f) Completed.
 - (g) General expressions for the sound pressure contributed by the thrust and torque have been derived in terms of the harmonic constituent of the unsteady inflow velocity field. Corresponding expression of the pressure signal for the hydrodynamic field, near acoustic field and far acoustic field have been deduced from the general formulae. Closed-form expressions for the near and far-acoustic fields have been developed in terms of complete elliptic integrals. Computations for the far acoustic field indicate that the pressure signal attributed to the variable loading is more persistent in the field than is so in the uniform inflow case.
 - (h) Davidson Laboratory Report No. 832, Feb. 1961.
- (3512) BLADE FREQUENCY PRESSURE NEAR AN OPERATING MARINE PROPELLER IN A WAKE.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
 - (c) Dr. J. P. Breslin, Director and Dr. S. Tsakonas, Head of Fluid Dynamics Division, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
 - (d) Theoretical; applied research.
 - (e) The purpose is to provide more realistic information than is at present available on the exciting forces generated by the transient flow produced by a marine propeller operating in the vicinity of a hull and its appendages. This information is essential for a study of the vibration of the hull as a whole as well as the hydroelastic behavior of plating and control surfaces. The linearized pressure is determined as the solution of a Dirichlet problem within the frame of Karman and Sear's non-stationary airfoil theory.
 - (f) Completed.
 - (g) General expressions for the vibratory pressure signal generated by the propeller have been derived in terms of Lipschitz-Hankel functions, and the propeller loading function which has been obtained by means of non-stationary airfoil theory. The results indicate that the non-uniformity of the incoming flow accounts for 10 to 40% of the total pressure signal.
 - (h) Davidson Lab. Report No. 857, Nov. 1961.
- (3514) THEORETICAL AND EXPERIMENTAL INVESTIGATION OF FLUTTER OF FULLY-WETTED HYDROFOILS.
- (b) David Taylor Model Basin, Office of Naval Research, Navy Department.
 - (c) Mr. Charles J. Henry, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson Street, Hoboken, N. J.
 - (d) Theoretical and experimental; basic research.
 - (e) Previous flutter investigations have shown disagreement between experimental results and theoretical predictions of the critical flutter speed of hydrofoils (see Henry, Dugundji, Ashley: "Aero-elastic Instabilities of Lifting Surfaces in High Density Media", Journal of Ship Research, Vol. 2, No. 4, March 1959). Experiments were carried out at several combinations of the parameters involved and the results were compared with theoretical predictions.
 - (f) Completed.
 - (g) The theoretical procedures commonly used by aeroelasticians were applied to predict the flutter speed of a rigid hydrofoil that had two degrees of freedom. The results, compared with corresponding experimental measurements, indicated a discrepancy between theoretical and experimental flutter speed at low density ratios; the predicted asymptotic behavior of flutter speed occurred, but at a lower density ratio. In addition, the accuracy of the circulation terms is more doubtful than that of the added mass and linear terms in the theory.
 - (h) "Hydrofoil Flutter Phenomenon and Airfoil Flutter Theory," by Charles J. Henry, Davidson Laboratory Report 856, Sept. 1961.
- (3516) INVESTIGATION OF HULL BENDING MOMENTS IN WAVES OF EXTREME STEEPNESS.
- (b) Ship Structure Committee.
 - (c) Mr. John Dalzell, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J.
 - (d) Experimental; applied research.
 - (e) Model tests were carried out to determine midship bending moments in very steep waves. Objective is to determine if an upper limit of wave bending moments exists. Six models were tested over a moderate range of speeds in waves of various lengths and several heights.
 - (g) Bending moment is found to be linear in waves of small and moderate steepness. Nonlinearity in bending moment appears with very high waves and its nature varies with wave length and model.
- (3517) SHIPS OF MINIMUM WAVE RESISTANCE.
- (b) Office of Naval Research, Department of the Navy.
 - (c) Dr. Milton Martin and Mr. James White, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
 - (d) Theoretical and experimental; basic research.
 - (e) To evaluate the agreement between computed and measured wave resistance of ship models of minimum wave resistance at high Froude numbers as determined from Weinblum's tables, in which the lines are modified to compensate for the boundary layer displacement thickness. The results of these tests will be compared with those of equivalent Taylor series models and a destroyer and with thin-ship computations.
 - (f) Completed.
 - (g) The results indicate the possibility of obtaining about 10% reduction in overall resistance over the Taylor Series model and about 8% over the destroyer at high Froude numbers, at the expense of poorer performance at low Froude numbers.
 - (h) Davidson Laboratory Report No. 845, May 1961.
- (3518) THE EFFECT OF HIGH SPEED ON LATERAL SHIP STABILITY.

- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Dr. Pung Nien Hu, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; basic research.
- (e) Conduct theoretical study of the effect of high speed on surface ship stability and maneuverability, including determination of lateral stability derivatives, stability indices and variations, and steady-state turning diameters.
- (f) Completed.
- (h) "Forward Speed Effect on Lateral Stability Derivatives," DL Report 829, by Pung Nien Hu.
- (3829) DEVELOPMENT OF SONIC WAVE PROBE FOR USE ON SHIPS.
- (b) Hydromechanics Laboratory, David Taylor Model Basin.
- (c) Mr. P. G. Spens, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N.J.
- (d) Experimental; development.
- (e) Determine the feasibility of using a sonic probe in conjunction with an accelerometer to measure the waves encountered by a moving ship when the system is mounted at the bow. The influence of the wave field projected by the ship must be determined. The effect of tilting the sonic probe and accelerometer on the recorded wave motion must be studied.
- (f) Completed.
- (g) In tests from a pier, a Bendix sonic altimeter showed some promise as a wave-measuring device. No further work is to be done as U. S. Hydrographic Office have initiated a much more elaborate project elsewhere.
- (3830) RADIATION OF A MARINE PROPELLER PRESSURE WAVE FROM ELASTIC PLATE AND CYLINDER.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Dr. S. Tsakonas, Head of Fluid Dynamics Div. and C. Y. Chen, Research Engineer, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) The purpose is to evaluate the sound pressure field radiated from the pulsating boundary of an elastic plate and cylinder when these are subjected to vibratory pressures generated by a marine propeller. This study will determine the extent of the contribution of the elastic boundary in amplifying the sound level generated by a propeller.
- (g) A formal solution for the case of an elastic cylinder has been obtained in the transform plane. Expressions for the velocity potential for the scattered and reduced waves with the corresponding pressure signals have been developed. Limiting cases for the far-acoustic field and near-hydrodynamic field are being considered.
- (3831) CORRELATION OF THEORETICAL RESULTS WITH EXPERIMENTS ON VIBRATORY THRUST AND PRESSURE.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Miss Winnifred R. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Applied research.
- (e) Experimental vibratory thrust and pressure results for various single-screw ship forms obtained at National Physics Laboratory, Hamburgische Schiffbau-Versuchsanstalt Gesellschaft, Netherlands Ship Model Basin and David Taylor Model Basin are to be correlated with theoretical results obtained on the basis of the work done in the following "A Theory for the Quasi-steady and Unsteady Thrust and Torque of a Propeller in a Ship Wake," by P. Ritger and J. P. Breslin, and "Marine Propeller Pressure Field Due to Loading and Thickness Effects," by J. P. Breslin and S. Tsakonas. If the correlation is close, charts will be constructed for use by naval architects in determining the pressure field and thrust fluctuations for proposed single-screw ship configurations.
- (f) Discontinued due to lack of the required data from the European Laboratories.
- (3832) FORMULATION OF EQUATIONS FOR SUBMARINE TRAJECTORIES WITH SIX DEGREES OF FREEDOM.
- (b) David Taylor Model Basin, Dept. of the Navy.
- (c) Mr. James White, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) Equations of a very general nature are being formulated to study the transient and steady state turning motion of deeply submerged submarines.
- (f) Completed. Preliminary report in preparation.
- (g) Partial differential equations for the motion of a deeply submerged submarine with six degrees of freedom are being written in accordance with the SNAME, "Nomenclature for Treating the Motion of a Submerged Body Through a Fluid". The hydrodynamic forces and moments will be expressed in terms of third order Taylor series expansions which contain all of the cross-coupling terms. Particular emphasis is being placed on the terms expressing roll instability due to yaw and pitch. The thrust exerted on the submarine is to be expressed as a function of speed of advance and propeller R.P.M. The effects of the interaction of bow planes on stern planes, the effect of propeller R.P.M. on stern plane effectiveness and the effect or changes in ballast are also included.
- (3833) EXPERIMENTAL AND ANALYTICAL STUDY OF FLUTTER OF SUBMERGED HYDROFOILS.
- (b) David Taylor Model Basin, Office of Naval Research, Navy Dept.
- (c) Mr. Charles J. Henry, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., Hoboken, N. J.
- (d) Experimental and theoretical; basic research.
- (e) To determine experimentally the conditions for flutter of submerged hydrofoils and to provide correlation of theory and experiment.
- (4220) ANALYTICAL INVESTIGATION OF COURSE STABILITY AND STEERING QUALITIES OF SHIPS.
- (b) David Taylor Model Basin.
- (c) Miss Winnifred R. Jacobs, Senior Research Engineer, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) Data available on 8 Taylor Series models are being reanalyzed in order to develop a rational method for estimating the course stability and steering qualities of ships.
- (4221) UNSTEADY FORCES AND MOTIONS ON A HYDROFOIL MOVING UNDER AN IRREGULAR SEA.
- (b) Office of Naval Research, Fluid Mechanics Branch, Dept. of the Navy.
- (c) Dr. S. Tsakonas, Head of Fluid Dynamics Div. and Mr. Charles Henry, Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical and experimental; applied research.
- (e) To determine by model tests and basic analytical studies the unsteady forces acting on a fixed, non-cavitating, finite-aspect-ratio hydrofoil and the motions of a single hydrofoil (elastically supported) when submerged and moving under an irregular

- seaway.
- (g) This project is in the formative stage.
- (4222) APPLICATION OF LIFTING SURFACE THEORY TO MARINE PROPELLERS.
- (b) David Taylor Model Basin, Bureau of Ships, Navy Dept.
- (c) Dr. J. Shioiri, visiting scientist from Tokyo University, and Dr. S. Tsakonas, Head of Fluid Dynamics Division, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) To adapt the existing lifting-surface theory of aerodynamics to the marine propeller case and to study the resulting surface integral equation for various chordwise and spanwise loading distributions. The purpose of this study is to evaluate the blade loading more realistically in terms of the geometric characteristics of the propeller and the inflow conditions, since the loading is immediately related to vibratory thrust and torque, to ship vibration and to underwater sound generators.
- (g) The surface integral equation has been derived and the case of a propeller with low-pitch angle is being studied.
- (4223) MARINE PROPELLER NOISE DUE TO BLADE THICKNESS.
- (b) Bureau of Naval Weapons, Navy Department.
- (c) Dr. S. Tsakonas, Head of Fluid Dynamic Division and Miss W. R. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) To investigate theoretically the effect of the propeller blade thickness on the pressure signal for the acoustic and hydrodynamic field cases.
- (4224) INFLUENCE OF AFTERBODY SHAPE ON ANGULAR HARMONIC CONTENT OF THE WAKE OF SINGLE SCREW SHIPS.
- (b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
- (c) Dr. J. P. Breslin, Director, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) Analyses of existing wakes of 20 foot models to determine the variation of 3rd, 4th and 5th blade angular harmonic coefficients with hull shape. Theoretical analysis of potential wake of thin ship forms having U- and V-shaped stern sections.
- (4225) INVESTIGATION OF SURFACE PIERCING STRUTS.
- (b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
- (c) Mr. John Dalzell, Chief of Ship Hydrodynamics Div., Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Experimental; applied research.
- (e) To determine the drag and side force on vertical surface piercing struts as a function of thickness, depth of submersion, angle of yaw and leading edge radius; and to segregate the various drag components including spray drag, profile drag, induced drag and tip drag.
- (4226) INVESTIGATION OF SURFACE-PIERCING FULLY VENTILATED DIHEDRAL HYDROFOILS.
- (b) Office of Naval Research, Department of the Navy.
- (c) Mr. P. Ward Brown, Chief of High Speed Craft Division, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson Street, Hoboken, New Jersey.
- (d) Experimental and theoretical; applied research.
- (e) A continuing investigation aimed at providing basic design information on three-dimensional hydrofoils operating near a water surface, under conditions of either fully ventilated flow or fully cavitating flow. To date the forces and moments on a series of surface piercing dihedral hydrofoils have been measured and the dynamics of systems employing such foils has been studied, including the problem of a hydrofoil impacting on the water surface and the stability of hydrofoil craft.
- (g) Analytical expressions for the forces and moments on surface piercing fully ventilated dihedral hydrofoils have been obtained and confirmed experimentally. A theory covering the impact phenomena of hydrofoils, and particularly applicable to seaplanes, has also been evolved and confirmed by experiment. A parametric study of the effect of system geometry on hydrofoil system dynamic stability has been completed. In order to check the stability theory a simple experimental free oscillation technique has been developed and has been used to obtain direct verification of the theoretical expressions for the stability derivatives. Forthcoming reports will present the findings of the stability investigation and will extend the data on forces and moments to include the effect of sweep and taper.
- (h) "Force and Moment Characteristics of a Surface-Piercing Fully Ventilated Dihedral Hydrofoil," by Gerard Fridsma, Davidson Lab. Report 795, October 1960.
- (4227) SMOOTH WATER BEHAVIOR OF SURFACE-PIERCING HYDROFOIL VESSEL.
- (b) Office of Naval Research, Fluid Dynamics Branch, Navy Dept.
- (c) Mr. A. Strumpf, Head Underwater Weapons Div., Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical and experimental; applied research.
- (e) An experimental and theoretical study is being made of the smooth water operation of a 110-ton craft supported by a tandem set of surface-piercing hydrofoils. The aim of the study is to develop equations of motion and obtain the hydrodynamic data necessary to permit the behavior of the hydrofoil boat to be predicted in the case of coupled six degree of freedom motions. Previous work has been restricted mainly to the study of the pure pitching and heaving motions of various types of hydrofoil systems.
- In the experimental phase of the present study, the rotating arm facility is being used to measure three orthogonal forces and three moments acting on each foil under a variety of combinations of depth, pitch angle, sideslip angle, roll angle, turning angular velocity, Froude number, and control surface angles. The results will yield realistic hydrodynamic data that can be used both in structural and motion analyses of the system.
- The steady turning performance of the vehicle will be predicted theoretically and compared with the experimental results. General dynamic stability criteria will be formulated and used to predict the stability of the vehicle. Various types of motions of the hydrofoil boat will be investigated theoretically, making use of theoretical and experimental force and moment data in the predictions.
- (g) The experimental results show that the lift developed by the rear foil is reduced appreciably by the pressure of the forward foil. The rear foil also ventilates under design conditions.
- (h) Progress Reports may be obtained through Correspondent.

(4228) FLUTTER OF HYDROFOILS ON FLEXIBLE STRUCTURES.

- (b) David Taylor Model Basin, Bureau of Ships, Dept. of the Navy.
- (c) Mr. Charles J. Henry, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., Hoboken, N. J.
- (d) Theoretical; basic research.
- (e) The variation of flutter speed and frequency will be found for a hydrofoil connected to a free-free beam. The effects of including varying numbers of modes for beam and foil will be investigated. In addition, the effect of beam parameters will be studied. The beam-foil system will, in the final analysis, represent as close as possible a ship-rudder system.

(4229) THE BOUNDARY LAYER UNDER PROGRESSIVE AND STANDING WAVES.

- (b) Office of Naval Research, Dept. of the Navy.
- (c) Dr. S. J. Lukasik, Chief, Fluid Physics Division, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Experimental, theoretical, and field investigations; basic research.
- (e) The purpose of this work is to study energy loss processes in shallow water waves. Theoretically, this is of interest because unsteady viscous flows have received relatively little attention, particularly the case of an oscillatory flow with no mean flow. Analytical and numerical solutions of the non-linear Navier-Stokes equations are under investigation. Laboratory measurements in the Stevens shallow water wave channel have been made of the wave attenuation coefficient of a progressive wave, the bottom shear stress under a progressive wave, and the time decay of standing waves. Field measurements of the bottom pressure and bottom velocity in 40 foot depths have been made off Block Island, R.I. These field measurements provide the possibility of determining the applicability of the laboratory measurements and the theoretical studies to the geophysical problem of the energy loss by ocean waves in shallow coastal waters.
- (g) It has been established by the laboratory experiments that there is an attenuation of shallow water waves that is in order-of-magnitude agreement with theoretical predictions. An analytical and numerical solution of the non-linear viscous problem has been obtained valid for short periods of time after start-up of a progressive wave. The field measurements of pressure and fluid velocity outside the bottom boundary layer show agreement with the predictions based on the potential flow statistical analysis of ocean waves.
- (h) "Attenuation of Shallow Water Waves," by C. E. Grosch and S. J. Lukasik, Bulletin Am. Phys. Soc. II 6 210(A) (1961).
"Measurement of Shallow Water Wave Shear Stress," by S. J. Lukasik and G. W. Zepko, Bulletin Am. Phys. Soc. II 6 211(A) (1961).

(4230) MEASUREMENT SMALL SURFACE WAVE AMPLITUDES.

- (b) Davidson Laboratory, Stevens Institute of Technology.
- (c) Dr. S. J. Lukasik, Chief, Fluid Physics Div., and Dr. K. D. Larsen, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Instrumentation.
- (e) The device measures the height of surface water waves of amplitude of the order of 0.001 inch. A styrofoam float is mounted on a light aluminum rod which in turn is fastened at right angles to the shaft of a rotary differential transformer. Surface elevation or depression causes a small angular displacement of the Schaevitz which is read out on a Sanborn Recorder. Calibration is accomplished by placing the float

in the water with the Schaevitz in a null position and raising or lowering the transformer by a micrometer head.

- (f) Completed.
- (g) Equipment has been successfully used for wave decay studies in the Davidson Lab. Wave Channel.
- (h) Publication in preparation.

(4231) PREDICTION OF TRAJECTORIES OF AN UNDERWATER MISSILE.

- (b) Bureau of Naval Weapons, Dept. of the Navy.
- (c) Mr. Howard Dugoff, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
- (d) Theoretical investigation; applied research.
- (e) The purpose of the project is to determine whether present knowledge of the forms of the equations of motion for underwater missiles and the numerical values used therein are accurate and complete enough to allow reliable trajectory predictions to be made. To this end, attempts are made to predict the motions of the Basic Finner Missile which have been measured previously in model scale studies. Both experimentally and theoretically derived force and moment data are utilized in the predictions. The IBM 1620 computer at Stevens is employed to obtain numerical solutions of the non-linear motion equations. In addition, exact or approximate analytic solutions are obtained whenever possible.
- (g) Predictions have been made corresponding to one and two dimensional trajectories (in both horizontal and vertical planes) encompassing laminar, turbulent, and transitional flows. In all cases the predicted motions are consistent with the previously measured trajectories.
- (h) Monthly progress reports have been submitted to the Bureau of Naval Weapons.

ROBERT TAGGART INCORPORATED.

(3836) ACOUSTIC EXCITATION OF FLAT PLATES IN A TURBULENT BOUNDARY LAYER.

- (b) David Taylor Model Basin, Department of the Navy.
- (c) Mr. Robert Taggart, Robert Taggart Inc., 400 Arlington Blvd., Falls Church, Va.
- (d) Experimental; basic and applied research.
- (e) Tests were conducted in a quiet gravity flow water tunnel with a thin, square, flexible, flat plate mounted flush with one wall. Hydrophone measurements were made of the pressure fluctuations in the turbulent boundary layer which were correlated with the boundary characteristics. Vibrations of the plate were measured by an accelerometer mounted on a diagonal. The maximum velocity range was from 5 to 15 feet per second.
- (f) Completed.
- (g) It is shown experimentally that pressure fluctuations from a turbulent boundary layer cause vibrations of a flexible flat plate at many natural modes. These fluctuations are related to the plate vibration amplitudes.
- (h) "An Experimental Study of Acoustic Excitation of Flat Plates by Unsteady Flow," Report RT-1101, 20 July 1961.

UNIVERSITY OF TENNESSEE, Hydraulic Laboratory, Department of Civil Engineering.

Inquiries concerning the projects listed below should be addressed to Dr. Harry H. Ambrose, Dept. of Civil Engineering, Univ. of Tenn., Knoxville 16, Tennessee.

(2159) DISCHARGE COEFFICIENTS FOR TAINTOR GATES ON

SPILLWAYS.

- (f) Suspended indefinitely.

(2619) BOUNDARY-ROUGHNESS EFFECTS UPON TURBULENT FLOW.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) Extended study of specific effects of certain characteristics of roughness-element geometry upon turbulent flow over rough surfaces.
- (f) Expansion of facility has been completed. Project will be reactivated in 1962.
- (g) Measurement of resistance characteristics and of velocity distributions have been made for 35 patterns of artificial roughness.

(3839) CHARACTERISTICS OF FLOW THROUGH A BOTTOM GRID.

- (b) Laboratory project.
- (d) Experimental; for master's thesis.
- (e) The effects of approach velocity, depth of flow, bottom slope, and grid conformation on the discharge through the bottom of a rectangular open channel were investigated.
- (f) Completed.
- (g) The results show the abrupt change in characteristic from partial to full diversion for three typical grid conformations. Discharge coefficients are referred to two-dimensional flow through the corresponding grid in a very large tank.
- (h) "Characteristics of Flow through Bottom-Grid Intakes" by G. Cisneros, 1961, M.S. Thesis, University of Tennessee, available on inter-library loan.

(3840) BOUNDARY PRESSURES ON CONDUIT ENTRANCES OF OPTIMUM DESIGN.

- (b) Laboratory project.
- (d) Experimental; for master's thesis.
- (e) Measurements of piezometric-head distribution were made on model conduit entrances in order to determine the extent of cavitation potentiality for three types of design.
- (f) Completed.
- (g) Results were consistent with those predicted by electrical analogy or relaxation techniques (done elsewhere) and emphasize the inertial effect of the diverted flow in relation to the shape of the opening in the plane boundary.
- (h) "An Experimental Determination of Pressure Distribution for Bellmouth Entrances of Optimum Design," by J. B. Marius, 1961, Master's Thesis, University of Tennessee, available on inter-library loan.

(3841) EXPANDING FLOW ON A SLOPING APRON.

- (f) Discontinued.

(4232) MAXIMUM/MEAN VELOCITY CORRELATION FOR ROUGH PIPES.

- (b) Laboratory project.
- (d) Analytical; for master's thesis.
- (e) An analysis was made of data from Project 2619 and selected data from Nikuradse to determine if a general correlation could be made of the maximum-to-mean velocity ratio (pipe factor) with mean-flow characteristics for artificially roughened pipes.
- (f) Completed.
- (g) An approximate general equation was determined for the pipe factor as a function of the Von Karman number only. Certain discrepancies appear in the Nikuradse data.
- (h) "Correlation of Pipe Factor with Mean-Flow Characteristics for Turbulent Flow of Water in Artificially Roughened Pipes," by Chao-yu Wu, 1961, Master's Thesis, University of Tennessee, available on inter-library loan.

TEXAS A AND M COLLEGE, Department of Oceanography and Meteorology, cooperative with Texas A and M Research Foundation, Dr. Archie M. Kahan, Exec. Director.

Inquiries concerning the following projects should be addressed to Prof. R. O. Reid, Texas A and M College, College Station, Texas.

(2868) INVESTIGATION OF STORM SURGES ALONG THE SOUTH SHORE OF NEW ENGLAND.

- (b) Beach Erosion Board, Corps of Engineers, U. S. Army, Contract DA-49-055-civ. eng. -56-4.
- (d) Numerical analysis; applied research.
- (e) Numerical and graphical procedures have been employed in the evaluation of tides and storm surge behavior in branching estuaries. Initiated Oct. 1955; completed 1961.
- (f) A numerical procedure for computation of water level changes in coastal bays and estuaries due to moving storm systems has been developed and tested for several different occurrences of hurricane surges for Narragansett Bay, Rhode Island. In the final program of computation, allowance has been made for the inclusion of astronomical tide with the storm surge so as to allow for possible interaction effects. Two different methods of evaluation of astronomical tide have been investigated.
- (h) Summary report in preparation.

(3519) DEEP-SEA MOORING OF SHIPS IN WAVES AND CURRENTS.

- (b) David Taylor Model Basin, U. S. Dept. of the Navy, Contract No. Nonr-2119(02).
- (d) Theoretical; basic research.
- (e) To determine the mooring line tensions arising from hydro-dynamic forces of waves and currents acting on a ship and mooring cable(s) in deep water.
- (g) The problem of steady state configuration of a deep-sea cable for a general distribution of current has been investigated and pertinent tables have been developed for facilitating the computation for a wide variety of mooring line situations. The more general problem of transient state of the mooring line is presently under investigation. Methods are being developed to allow an evaluation of dynamic tension and deflections relative to a reference steady configuration for given input conditions at the upper end of the mooring line.
- (h) "Characteristics of Deep-Sea Anchor Cables in Strong Ocean Currents," by B. W. Wilson, Tech. Report No. 204-3, Texas A and M Research Foundation, February, 1961, 81 pp.
- "Characteristics of Deep-Sea Anchor Cables in Strong Ocean Currents - Tables of Values," by B. W. Wilson, Tech. Report No. 204-3A, Texas A and M College Research Foundation, March 1961, 266 pp.

(3520) FORECASTING OF OCEAN WAVES GENERATED BY MOVABLE VARIABLE WIND SYSTEMS IN DEEP AND SHALLOW WATER.

- (b) Engineering Foundation, New York; Sacony-Mobil Oil Co., Dallas; Humble Oil and Refining Co., Houston; Office of Naval Research, U. S. Navy, Contract N7 onr 48702 (Project No. NR 083-036).
- (d) Theoretical and empirical; basic and applied research.
- (e) To verify a moving fetch variable-wind graphical forecasting procedure by direct comparison of results with wave observations at one or more offshore stations. Thence to investigate the possibility of extending the method to rapid forecasting of wave conditions in near-shore environments where water depth, friction and refraction are complicating factors in wave generation.
- (f) Initiated Feb. 1959; completed 1961.
- (g) Analysis is being made of the sea conditions induced by hurricane "Audrey" of June, 1957.

Complete synoptic maps for the Gulf of Mexico area have been prepared, showing the surface pressure patterns wind distributions and circulations at intervals of 3 hours from June 25 to June 28. From these space-time wind-fields for five different lines of approach to the Louisiana coastline have been obtained. The original graphical wave forecast method for dealing with moving wind systems over deep water has been adapted to a high speed digital procedure which can be processed on an IBM 704 or 709 computer. Application to the hurricane "Audrey" windfields is proceeding and the method is being further adapted to shallow water. A re-analysis of basic observational wave data has been undertaken to improve wave forecasting accuracy if possible.

- (h) "Deep Water Wave Generation by Moving Wind Systems," by B. W. Wilson, Journ. Waterways and Harbors Div., Proc. ASCE, (2821): 113-141, 1961.
- (4233) THE EXCHANGE CHARACTERISTICS AND SALINITY REGIME OF SHALLOW WATER BAY SYSTEMS.
 - (b) National Science Foundation, Grant NSF-G19780.
 - (d) Analysis methodology; applied research.
 - (e) The object is to develop a numerical model which can reproduce the temporal changes in the gross features of the salinity distribution in a shallow bay in response to changes in control factors and to determine changes in the variance spectrum of the detailed features as related to the spectral statistics of the control factors.

UNIVERSITY OF TEXAS, Department of Civil Engineering.

Inquiries concerning Projects Nos. 2162, 2396, 2397, 2629, 2874, 3524, 4234 and 4235, should be addressed to Dr. Walter L. Moore, Dept. of Civil Engineering, Univ. of Texas, Austin 12, Texas.

- (2161) CHARACTERISTICS OF A HYDRAULIC JUMP AT AN ABRUPT CHANGE IN BOTTOM ELEVATION.
 - (b) University of Texas Research Institute and Bureau of Engineering Research.
 - (c) Dr. Carl W. Morgan, Assoc. Prof. of Civil Engineering, Univ. of Texas, Austin, Texas.
 - (d) Experimental.
 - (e) Experimental determinations are made of the flow characteristics at two-dimensional channel drops and rises. The velocity distribution and surface profile will be determined throughout the length of the jump for various relative changes in bottom elevation. The longitudinal location of the jump in relation to the change in bottom elevation will be varied over a broad range in distinction to previous related investigations in which relative location of the jump was held constant.
 - (g) Results for the abrupt drop are complete and have been published. For a given entering Froude number lying between 2 and 8 three types of jump may form, the type and its longitudinal location depending only on the relative downstream depth. The velocities near the bottom below the drop are always less than the mean velocity in the downstream channel for the jump type of maximum height. Experimental measurements have been made on the related investigation for an abrupt rise and report is being prepared.

(2162) HYDROLOGIC STUDIES, WALLER CREEK WATERSHED.

- (b) Cooperative with U. S. Geological Survey.
- (d) Field investigation; applied research.
- (e) Measurements of rainfall and runoff for a 4 square mile and a 2 square mile portion of the Waller Creek watershed are being made to provide basic information for estimating runoff from small urban watersheds in the

Southwest area. Two stream flow stations and a rain gage net are in operation. Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin are being made by various proposed methods to serve as a base for comparison with the data as it is collected from the stream.

- (g) Careful estimates of the peak discharges at the gaging station were made by various proposed methods based on measurable characteristics of the basin. These results will be of interest to compare with observed peak discharges in later years when the record is long enough to be significant.
- (h) "Peak Discharge Predictions for Waller Creek at 23rd Street at Austin, Texas," by William H. S. Diehl, M. S. Thesis, 1959.

(2396) RESISTANCE OF PIERS IN FREE SURFACE FLOW.

- (b) Laboratory project.
- (d) Theoretical and experimental (thesis).
- (e) An investigation is being made of the drag resistance of piers as a function of shape, relative submergence, spacing, and Froude numbers. The pier resistance is being correlated with the head loss for flow in a channel.
- (g) A phase of the investigation has been completed for Froude numbers less than 0.5 with cylindrical piers at various submergence and spacing. An investigation of the resistance of H section piers at various orientations and longitudinal spacings has been completed. Another phase has been completed which demonstrates that the velocity gradient along a cylindrical pier affects the drag coefficient. The local drag coefficient decreases along the pier in the direction toward the end of the pier where the velocity is high. The reduction in drag coefficient is related to a dimensionless measure of the velocity gradient along the cylinder.

(2397) EFFECT OF UPSTREAM DEVELOPMENT ON THE RUNOFF FROM SMALL WATERSHEDS IN THE SOUTHWEST.

- (b) Laboratory project.
- (d) Field investigation (thesis).
- (e) For a selected watershed rainfall and runoff relations before the period of upstream development are being analyzed. The relations obtained for this period will be applied to the rainfall records after the upstream development and the predicted runoff compared with the actual runoff.
- (g) Sources of data have been located. The available information tabulated, and a method of evaluating the runoff devised that appears to be reasonable. Multiple correlation diagrams have been developed which may be used with storm rainfall records to predict the annual runoff of the selected watershed for the period before upstream development.

(2629) A MECHANICAL TURBULENCE INDICATOR FOR LIQUIDS.

- (b) Bureau of Engineering Research, Univ. of Texas.
- (d) Experimental instrument development.
- (e) There is need for a relatively simple device to give a quantitative measure of the degree of turbulence in a flowing fluid. Electrical instruments commonly measure the root mean square of the turbulent fluctuations as an indication of the intensity. The instrument being developed measured the maximum turbulent fluctuation as an indication of the intensity. The instrument is similar to a 1/2-inch diameter Prandtl velocity tube except that it has two stagnation openings; the conventional one which gives the mean stagnation head and an additional one which leads through a

- sensitive check valve and accumulator elements are located in the tube less than 3/8 of an inch from the stagnation opening to minimize inertia effects.
- (g) The instrument has been built and calibrated. Measurements have been made to evaluate the operation of the instrument in the turbulent field of a hydraulic jump. A report is being prepared describing the instrument, the calibration technique and the results in the hydraulic jump.
- (2874) AN INVESTIGATION OF THE SCOUR RESISTANCE OF COHESIVE SEDIMENTS.
- (b) Bureau of Engineering Research, Univ. of Texas, Austin, Texas.
- (d) Analytical and experimental (laboratory).
- (e) Exploratory tests have been made with two different schemes, one with radially outward flow between a circular disk and the soil sample, and one with a submerged vertical circular jet impinging on a horizontal soil surface. With the first scheme it was not possible to obtain the necessary precision of measurement at low scour rates, but with the second scheme satisfactory measurements were obtained. A correlation based on dimensional analysis gave consistent results in evaluating the relative scour resistance of several materials. Apparatus is being fabricated for a new test which is expected to permit direct evaluation of the shear stress at the soil surface. In this test a cylindrical soil sample is submerged in a transparent concentric cylinder which can be rotated at a controlled speed to generate a shear stress on the soil surface. An attempt will be made to relate the scour resistance to other measurable soil properties, and finally to interpret the results in relation to field observations.
- (g) The apparatus to determine shear stress at the soil surface has been constructed and calibrated, and preliminary tests have been conducted on a soil sample.
- (h) "Experiments on the Scour Resistance of Cohesive Sediments," by Walter L. Moore and Frank D. Masch, Jr., paper presented before Symposium on Sedimentation, American Geophysical Union, Washington, D. C., April 18, 1961.
- (3522) LONG TIME FLUCTUATIONS IN STREAM RUNOFF.
- (b) Laboratory project.
- (c) Dr. Carl W. Morgan, Dept. of Civil Engrg., Univ. of Texas, Austin 12, Texas.
- (d) Analytical and field study.
- (e) Values of runoff from selected drainage areas in the lower Mississippi River Basin and in basins of the rivers emptying directly into the Gulf of Mexico were studied. Variations in the runoff values for each stream were considered and these trends compared with solar variations. The relative sunspot numbers were used as the measure of solar variations and were correlated with the mean annual runoff. Further correlations are being made with different "lag" periods between solar activity and surface runoff.
- (g) The gradual shifting of the centers of runoff excess and deficiency is consistent rather than random and appears to represent a gradual cyclic change in the runoff pattern. It appears that the locations of the centers of runoff deficiency are following roughly the same path that it did some 22 to 24 years previously. Correlation coefficients of plus 0.2 to plus 0.5 are obtained for selected rivers in Mississippi, Alabama, Georgia, and Arkansas when sunspot numbers in the 11-year sunspot cycle are correlated with runoff. Texas streams do not give significant correlation with the 11-year sunspot cycle but give better correlation if runoff is compared with the double sunspot cycle in which sunspot numbers are assumed as negative in alternate cycles.
- (3524) GROUND WATER FLOW AND SEEPAGE IN NON-HOMOGENEOUS, NON-ISOTROPIC SEDIMENTS.
- (b) Laboratory project.
- (d) Theoretical, basic.
- (e) A relaxation solution for the Laplace equation has been developed which is applicable across a boundary between two regions of different permeabilities. It is believed that the method can be expanded to apply to any specified non-homogeneous and non-isotropic condition. It is intended that the solution be set up for computation on an electronic computer and that selected numerical solutions be checked against those from an electrolytic tank.
- (4234) EVAPORATION REDUCTION BY CONTROL OF ADVECTED ENERGY.
- (b) Partial sponsorship by the Lower Colorado River Authority of Texas.
- (d) A masters thesis involving theoretical and field investigation.
- (e) A study will be made of temperature variation in a reservoir and of the in-flow and out-flow of the reservoir to explore the possibility of reducing the evaporation by control of the advected energy. An effort will be made to estimate the effect of making releases from water near the surface.
- (4235) TWO-PHASE FLOW IN CONDUITS.
- (b) Laboratory project.
- (d) Experimental master's thesis.
- (e) It is apparent that for a two-phase flow system with a liquid and gas, many different types of flow are possible. This investigation will explore the use of sound measurements to detect the type of flow present, in a metal pipe. Various types of flow will be established in parallel lines; one of steel and one of a transparent material to permit visual observation of the flow. Records will be made of the sound pattern from a sound pickup on the wall of the pipe, the pressure variations at a wall piezometer, and the pressure drop in the pipe. If a sonic identification of the flow type can be made, it will be helpful in solving operation problems with pipe lines and process plants as well as providing a means for determining the frequency of occurrence of the various flow types.
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- UTAH STATE UNIVERSITY, Engineering Experimental Station.
- (3183) DYNAMICS OF FLOW IN STEEP, ROUGH, OPEN CHANNELS.
- (b) Laboratory and field project.
- (c) Dr. Dean F. Peterson, Dean of Engineering, Utah State University, Logan, Utah.
- (d) Experimental, theoretical, field investigation; basic research for doctoral theses.
- (e) A basic study of relationships involved in flow in steep, rough channels where the roughness is relatively an appreciable part of the depth, and where channels are sufficiently steep or steeper than a slope such that supercritical flow can occur in connection with contractions caused by the roughnesses. The work is basic, however, it will have application to steep mountain streams and to hydraulic structures. The objective of the work is to relate descriptive parameters describing the size and configuration of the bed roughness to slope, depth and discharge of channels of this class. Studies began using simple bar and cube roughness elements and have progressed through the use of beds formed by giving natural gravel elements of various

size, gradation and intensity to the bed. Field studies will be made at several sites of the detailed statistical nature of the bed configuration. Flow measurements and slope will also be made at the same sites. An attempt will be made to relate field results to flume studies.

- (g) Flow regimes have been classified into three major regimes and several sub-regimes. Studies using bar and cube roughness elements have been completed and criteria delineating the various regimes have been established. Flow equations have been developed. Three sizes of graded gravel elements, having maximum sizes 4", 3" and 2" and three values of intensity in the ratio of 1, 4, 8 were tested under flume conditions. Some 500 runs led to good correlations of the form

$$V = C_1 \left(\frac{D}{a_0} \right)^{1/3} \left(\frac{1}{a_1} \right)^{1/3} \sqrt{gDs}$$

for tranquil and tumbling regimes and to

$$V = C_2 f \left(\frac{1}{a_2} \right) \sqrt{gDs}$$

for rapid flow. In these equations a_0 , a_1 , a_2 are roughness size parameters for the graded beds, l is a spacing parameter, D is a piezometric depth connected to the mean bed level of roughness, and f is a functional relationship experimentally determined.

- (h) "Two-dimensional Flow in Steep, Rough Channels," Abbas H. Al-Khafaji. Thesis presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Utah State University, 1961. "Flume Studies of Flow in Steep, Rough Channels with Natural Roughness Elements," by Najib S. Kharrufa. Thesis presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Utah State University, 1962. "Roughness Spacing in Rigid Open Channels," by William W. Sayre and M. L. Albertson. Discussion by Dean F. Peterson. Publication pending. Journal of Hydraulics Division. Proceedings of American Society of Civil Engineers.

(3185) HYDRAULICS OF SURFACE IRRIGATION.

- (b) Laboratory research.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, theoretical; basic research.
(e) Hydrodynamic and field study of movement of water over a porous surface when intake varies with time. Free surface and the rate of advance are defined.
(g) Differential equations have been obtained defining the free surface and the rate of advance. Solutions have been compared with field measurement of the rate of advance. The results are within ten percent of field observations. High speed computers to obtain typical solutions will be used. A companion study is based upon utilizing empirical relationships as a foundation for subsequent development of rate of advance functions. The results compare well with measured values.
(h) "The Intake Rate as Related to the Advance of Water in Surface Irrigation," by J. E. Christiansen, A. A. Bishop and Yu-Si Pok. Presented at the 1959 winter meetings of the American Society of Agricultural Engineers, Chicago, Illinois. "Mathematical Relationships Expressing the Hydraulics of Surface Irrigation," V. E. Hansen. Proceedings of the ARS-SCS Workshop of Hydraulics of Surface Irrigation, ARS 41-43, USDA, October 1960. "The Importance of Hydraulics of Surface Irrigation," by V. E. Hansen, Journal of Irrigation and Drainage Division. Proceedings of American Society of Civil Engineers, Sept. 1958.

"Average Depth of Absorbed Water in Surface Irrigation," F. W. Kiefer, Jr., Civil Engineering Dept., Utah State University, Logan, Utah, 1959. (Mimeographed)

(3186) GROUND WATER MOVEMENT IN A NON-HOMOGENEOUS, ANISOTROPIC MEDIA.

- (b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, theoretical; basic research.
(e) A variable resistance network has been developed wherein problems of non-homogeneous anisotropic flow can be evaluated. This network has been used to establish the procedure, validity and accuracy of solutions which can be expected from this approach. Boundary conditions necessary for unique solutions and the method of application of boundary conditions have been studied.
(f) Completed.
(h) "The Development of an Electrical Analog for Non-Homogeneous Anisotropic Soils," by K. R. Craig, Civil and Irrigation Engineering Department, Utah State University, 1958. "Conductivity Variation in Anisotropic and Non-Homogeneous Conducting Media Defined by Stream Function and Potential Function Relationships Using A Variable Resistance Electrical Analog," by David W. Hendricks, Civil and Irrigation Engineering, Utah State University, Logan, Utah, 1960.

(3525) MEASUREMENT OF FLOW FROM HORIZONTAL PIPE BY THE COORDINATE METHOD.

- (b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental; theoretical; applied research.
(e) The error involved in the conventional method of measurement is shown to be large. The coefficient has been defined and parameters developed so that more accurate measurements can be obtained in a quick, easy method of water measurement.
(f) Completed.
(h) A bulletin outlining field procedure to be followed with the method is now being prepared.

(3527) DEVELOPMENT OF LOW COST WATER LEVEL RECORDER.

- (b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, development.
(e) In general, the available instrumentation for measuring fluctuation in water level is costly. Most equipment is designed for a wide range of application. However, many areas require only a limited fluctuation in water level. This is particularly true in irrigation practice. Objective of the project is to develop a low-cost recorder which will fit these needs and thereby permit a more extensive use.
(g) A water level recorder has been developed which does meet the requirements and is now being modified and adapted for commercial production.

(3528) THE EFFECT OF SEDIMENT PROPERTIES ON THE ATTENUATION OF AN ULTRASONIC PLANE WAVE.

- (b) National Science Foundation.
(c) Dr. Gordon H. Flammer, Civil and Irrigation Engineering Department, Utah State Univ., Logan, Utah.
(d) Theoretical and experimental; basic research.
(e) Some theoretical and experimental work has been performed on the attenuation of an ultrasonic plane wave passing through a

- sediment suspension. However, prior work is still very limited in scope, particularly over certain loss regions. This study is using a standard pulse technique to investigate a wide range of sediments both natural and manufactured over the various loss ranges. Of primary concern is the effect of the various sediment properties on the attenuation.
- (g) Natural sediments have been completed and an M. J. thesis is currently being prepared giving the results. Manufactured sediments of known properties are now being tested and a Ph.D. dissertation will result from this study.
- (3529) DEVELOPMENT OF LOW COST IRRIGATION WATER METER.
- (b) Cooperative with Irrigation Dept., Univ. of California, Davis, California.
- (c) Mr. Jerry E. Christiansen, Professor of Civil and Irrigation Engineering, Utah State University, Logan, Utah.
- (d) Experimental; applied research-development.
- (e) Tests on the use of a domestic type water meter as a by-pass meter for irrigation service were conducted on three types of primary head producing divisions for use with water meter.
- (f) Experimental work completed.
- (g) Results indicate that a small domestic type of water meter can be employed as a by-pass meter for measuring large flows in pipe lines with a fair degree of accuracy.
- (h) Manuscript in preparation.
- (3530) WATER REQUIREMENTS OF WILDLIFE AREAS.
- (b) Utah State Fish and Game Dept., Salt Lake City, Utah.
- (c) Mr. Jerald E. Christiansen, Professor Civil and Irrigation Engineering, Utah State Univ. Logan, Utah.
- (d) Field investigations; applied research.
- (e) Large areas of marshy lands adjacent to Great Salt Lake have been developed and improved by the State Fish and Game Dept., and the Federal Wildlife Service, as Migratory Bird Refuges. Available streams flow from several of the major streams flowing into these areas where the water is impounded behind dikes to create habitat suitable for nesting, feeding and resting of water fowl. Millions of ducks and geese utilize this area each year during their migratory flights.
- (g) The basic purpose of the study is to determine the quantities of water necessary for this area in order to maintain them in a productive state.
- (h) Several progress reports have been written.
- (3842) DEVELOPMENT OF PREFABRICATED IRRIGATION STRUCTURES.
- (b) United States Steel Corporation.
- (c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
- (d) Experimental; and applied research and design.
- (e) This project has been conducted to develop a low-cost prefabricated irrigation structure that can be easily installed by unskilled workmen, and can be adapted to many sizes and shapes of ditches. It is versatile in that it can be used as a division box, turnout, check, drop, gate, etc. Measuring devices are being developed to add to its many uses. Sizes, shapes, thickness or material to be fabricated, and fastening devices were studied. Effects of frost and ditchbank stresses are also evaluated.
- (f) Completed.
- (g) The results will benefit farmers, ranchers and gardeners throughout the nation in that it answers a need for a prefabricated water control structure.
- Design and field testing is complete. Preparations are now being completed to mass produce and market the components.
- (3843) A SHAPE AND FRICTION FACTOR RELATIONSHIP BETWEEN SMOOTH, RECTANGULAR, AND CIRCULAR CHANNELS.
- (b) Laboratory project.
- (c) Dr. Gordon H. Flammer, Associate Professor, Civil and Irrigation Engineering Dept., Utah State University, Logan, Utah.
- (d) Theoretical; basic research for master's thesis.
- (e) This study has been made to determine a shape factor relationship so that the friction factors (Moody curves) for circular pipes can be used with rectangular shaped channels. To accomplish this, head loss data has been taken, through a wide range of Reynold's numbers, from a number of rectangular channels varying from approximately a square to a channel approximately 3/8 inches by 4 inches.
- Only one material was used in constructing the channels and the narrow dimension of the channel was held constant.
- Friction factor values for circular pipe have often been used for shapes other than circular; and for shapes that are not too far from a circle. The error isn't appreciable; however, for channels that are far removed from a circle.
- (f) Completed.
- (g) It is anticipated that this study will result in more realistic friction factors for rectangular channels.
- (3844) THE REMOVAL OF HIGH TURBIDITY WITH RAPID SAND FILTERS.
- (b) Laboratory project.
- (c) Prof. Elliot Rich, Civil and Irrigation Engineering Department, Utah State Univ., Logan, Utah.
- (d) Experimental, theoretical; basic research for a master's thesis.
- (e) A study of the efficiency of rapid sand filtration was conducted under conditions of varying initial turbidity and application rate. The turbidity ranged from 50 to 400 parts per million and the flow rate from .25 to 5.5 gal/min/ft² of filter area. The same sand 0.505 mm mean diameter, was used in all the tests; and its depth was held constant at 30 inches. The filter was constructed from a plastic tube, 3-1/2 inches in diameter to minimize wall effects, and was equipped with an overflow so a constant head of 44 inches would be maintained above the sand.
- (f) Completed.
- (g) The results of this experiment indicates that rapid sand filtration could be used as a means of pretreating water if initial turbidity is under 200 parts per million and flow rate is maintained below 4 gallons per minute per square foot. To obtain a finished product with a turbidity under 10 parts per million or initial turbidities greater than 200 parts per million multiple filtration should be used with the effluent from one filter being fed directly to the next filter.
- (h) "The Removal of High Turbidity with the Rapid Sand Filter," Murray L. Corry, M.S. Thesis, Civil Engineering Department, Utah State University, Logan, Utah, 1961.
- (3845) WATERSHED MODEL STUDIES.
- (b) Agricultural Research Service, U. S. Dept. of Agriculture.
- (c) Prof. Jay M. Bagley, Civil and Irrigation Engineering, Utah State University, Logan, Utah.
- (d) Experimental; basic research for master's thesis.
- (e) The purpose is to establish techniques and

- model-prototype laws so that watersheds can be intensively studied in a laboratory. For this study, a small watershed is being modeled in size, shape, and topography encompassing provisions for varying the permeability of the model's surface. Water to represent precipitation in various patterns will be applied over the model watershed. By the nature of the proposed study, the dominant factors influencing the characteristic shape of the run-off hydrography are:
- (1) Watershed shape; (2) rainfall intensity; (3) rainfall duration; and (4) time element being a function of a composition roughness factor.
- The study is divided into two phases. In the first phase, the object is to simulate the run-off hydrography using a physical model with an impervious surface. Thus, it is known that the simulated hydrograph will be distorted volumetrically. The second phase has the same objective as the first, except refining the simulation by removing the distortion of run-off volume. The second phase has the added objective of an investigation of the relationship between infiltration and run-off.
- (g) A better understanding of the parameters influencing the rainfall-run-off relationship of arid southwestern watershed are being obtained. Ultimately, this will result in better design of structures built to contain, convey, or bridge the run-off water of this area.
- (3846) CONSTRUCTION OF AN INTERSTATE HIGHWAY ACROSS THE SALT FLATS NEAR WENDOVER, UTAH.
- (b) Utah State Road Commission.
 - (c) Prof. Jerry E. Christiansen, Civil and Irrigation Engineering, Utah State Univ., Logan, Utah.
 - (d) Field investigation for design and development of Interstate highway.
 - (e) The design and construction of an interstate highway across the salt flats near Wendover, Utah, poses a number of problems that require solutions. This is one of the few places in the world where a highway must be built over a salt bed. The maintenance of the present highway and railway that traverses these salt flats has been difficult. It is hoped that a better understanding of the problem, based on extensive field and laboratory investigations of materials on which the highway will be built, will result in a design that will be relatively free of maintenance problems. The objective, therefore, is to fully determine the characteristics of the salt bed and the underlying soil materials to considerable depth. The work completed to date has been concerned primarily with the permeability of the sub-soil materials to the flow of water. Surprisingly, it has been found there are very permeable strata underlying the salt. These are of considerable concern because of the movement of partially saturated solutions through these permeable zones which tends to dissolve and remove salt, resulting in uneven settlement of the roadway.
 - (g) A sound and economic design depends upon a complete knowledge of the materials involved. Investigations should be of definite practical value in determining the basic requirements for the design and construction of the multimillion dollar highway, which will be built within the next few years. Economies in design should result from the studies being undertaken.
 - (h) Several progress reports have been written.
- (4236) METHODS FOR PREDICTING MEAN ANNUAL WATER YIELDS IN UTAH.
- (b) Utah Water and Power Board and Utah State Engineer.
 - (c) Prof. Jay M. Bagley, Civil and Irrigation Engineering Dept., Utah State University, Logan, Utah.
 - (d) Experimental; applied research.
 - (e) This work was undertaken to develop methods of obtaining economical and reasonably accurate determinations of watershed yield where stream gaging records are not available. Certain relatively easily obtained parameters characterizing the physical and climatic factors have been correlated with water yield for a number of watersheds having good records of stream flow.
 - (f) Completed.
 - (g) Regression equations have been developed for estimating water yield from physical characteristics of basins in various regions of Utah. Based on the developments of this study, a water yield map for the entire state of Utah is being prepared. The map, equations and graphs should aid materially in broadening the coverage of hydrologic information needed for first stage planning of a long range state-wide nature.
 - (h) "A Method for Predicting Surface Run-Off from Watersheds with Limited Hydrographic Data," by Roland W. Jeppson, Master's Thesis, Utah State University, 1960.
"Methods for Predicting Mean Annual Water Yields in Utah," by Jay M. Bagley, Roland W. Jeppson, Yin Auyeung, Cleve H. Milligan. (Manuscript in preparation.)
- (4237) EFFECT OF VARIOUS IRRIGATION TECHNIQUES ON SOIL AERATION, SOIL STRUCTURE AND CROP RESPONSE.
- (b) Utah Agricultural Experiment Station (State Funded Project #591).
 - (c) Prof. Jack Keller, Utah Agricultural Expt. Station, Utah State University, Logan, Utah.
 - (d) Laboratory, experimental and field investigations; applied research.
 - (e) Where saturating rainfalls are infrequent it appears likely that land productivity is closely related to the effects of irrigation on soil aeration and structure. With present day irrigation technology, the design engineer and irrigator have some degree of control over both soil aeration and structure; however, the extent of control and effects on crop response have not been determined. This project proposes to develop criteria (useful in the design and management of irrigation systems) based on crop responses as affected by soil aeration and structure. A review of literature shows that bulk structural tests such as capillary rise, moisture release, modulus of rupture and various permeability measurements have given indexes that can be related to crop response. In order to establish limits for the proposed field investigations, it is the intent that the first phase of the project be a laboratory study of simulated field irrigation techniques.
 - (g) This project is still in the beginning processes of an extensive review of literature and preparations for the initial laboratory set-up.
- (4238) OPEN CHANNEL FLOW OVER SINGLE REGULAR LARGE ROUGHNESS ELEMENTS.
- (b) Laboratory project.
 - (c) Dr. Dean F. Peterson, Dean of Engineering, Utah State University, Logan, Utah.
 - (d) Experimental, basic research for master's and doctor's degrees.
 - (e) A detailed study was made of the configuration of free surface gravity flow over and around a cubical, hemispherical and semi-disc elements of relatively large size in proportion to depth. Piezometric measurements were made at a number of points on the surface of the elements. Drag forces and, where applicable, drag coefficients were computed.
 - (f) Completed.
 - (g) Drag forces were related to flow velocity

and relative submergence. In some cases flow was accelerated beyond supercritical in the neighborhood of the element resulting in localized hydraulic jumps downstream. At high velocities, the element was encased in an air bubble formed by the impact streams around the element. Detailed maps and photos of water surface disturbances and wake patterns were made showing progress of these changing conditions of depth and approach velocity.

- (h) "Pressure Distribution and Flow patterns Around a Cube in Open Channel Flow," by Abdelbagi Omer Attieh, Thesis presented in partial fulfillment of the requirements for the degree of Master of Science, Utah State University, 1961.
- "Effect of Single Large Roughness Elements in Open Channel Flow," by Ambadas G. Mirajgaoker, Thesis presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Utah State University, 1961.
- (4239) MECHANICS OF EVAPOTRANSPIRATION.
 - (b) Laboratory.
 - (c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
 - (d) Theoretical; basic research.
 - (e) An analysis of water movement from the soil, through the plant and into the atmosphere is made using basic hydraulic properties of flow. The mechanism of water transmission within the plant is given particular attention.
 - (f) Completed.
 - (h) "Mechanics of Evapotranspiration," by David W. Hendricks and Vaughn E. Hansen. Publication pending. Journal and Transactions of American Society of Civil Engineers, 1962.
- (4240) THE INFLUENCE OF PRECIPITATION CHARACTERISTICS ON THE WATER AVAILABLE FOR DOWNWARD MOVEMENT INTO THE SOIL.
 - (b) Western Soil and Water Research Project with 12 western states collaborating through U.S.D.A. and State Agricultural Experiment Stations.
 - (c) Mr. C. H. Milligan, Head Civil and Irrigation Department, Utah State University, Logan, Utah.
 - (d) Theoretical and experimental; applied research. One M.S. degree candidate is working on the project at present.
 - (e) The purpose of the project is to delineate the characteristics of precipitation including intensity, drop size, terminal velocity, angle of attack, etc. which affect interception and infiltration of the precipitation, and to find functional relationships which relate these characteristics to infiltration and interception.
 - (g) Project active but just getting underway.
- (4241) IMPROVEMENT OF STREAMFLOW FORECASTING.
 - (b) Laboratory project.
 - (c) Mr. C. H. Milligan, Head, Civil and Irrigation Dept., Utah State Univ., Logan, Utah.
 - (d) Experimental, theoretical, and field; applied research.
 - (e) The purpose of the project is to develop procedures for utilization of antecedent precipitation, temperature, soil moisture, runoff, and snow survey data in the prediction of streamflow for the coming irrigation season. The procedure is largely statistical and is programmed for high speed computer solutions. Trigonometric series are used to represent trends in antecedent rainfall, temperature, soil moisture, and streamflow. The Fourier coefficients along with total water content of the snow cover on a given prediction date are correlated with runoff

by months. Regression coefficients determined from data from the past are utilized in equations to complete the predicted values.

- (g) Results are promising but a longer record is needed to test the validity of the procedures.
- (h) "The Use of Fourier Series in Streamflow Forecasting," by C. H. Milligan, Proceedings Western Snow Conference, 1956.

WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Dr. E. Roy Tinney, Head, The R. L. Albrook Hydraulic Laboratory, Division of Industrial Research, Washington State University, Pullman, Washington.

- (1689) STUDY OF FLUID FLOW IN PIPE NETWORKS.
 - (b) Personnel responsible for the design and/or operation of water and gas distribution systems.
 - (d) Analyses by analogue and digital computers.
 - (e) Flow distributions have been made with the McIlroy Analyzer for over 50 cities, several gas systems, an air system, a generator cooling system, and several other unique systems. Losses throughout the system are obtained. Engineers use the analogue to design system pumps, tanks, and piping additions or revisions.
- (2631) ROCKY REACH HYDROELECTRIC DEVELOPMENT.
 - (b) Chelan County Public Utility District No. 1.
 - (d) Experimental; design.
 - (e) A 1:75 scale model, 109 feet long by 40 feet wide, of the Rocky Reach Hydroelectric Development and 7500 feet of the Columbia River has been constructed to study (1) river flow characteristics during prototype construction stages and (2) the operation of the completed development. Studies have been completed on the cofferdam layouts and tests on the operation of the spillway are now in progress. A 1:44.9 scale model of two spillway bays has been constructed and installed in a glass-sided flume to determine specifically the design of the energy dissipation scheme which consists of baffles on the apron and nappe deflectors on the ogee spillway. A 1:45 scale model of four bays of the truncated spillway was built and tested to determine causes of and remedial measures for apron erosion created by the diverted river flow. A 1:45 scale model of seven bays of the spillway has been built and is being tested to determine the limits of a nonuniform spillway gate operation which might be detrimental to the baffle system. Tests were also made on this model to determine whether any damaging spillway gate vibrations would result from large vortices which appear upstream from the gates.
 - (g) Erosion that occurred during diversion stages was caused by gravel which was forced over the diversion slots from upstream. This gravel was entrained in the flow on the apron and eventually eroded sizeable holes in the apron.
 - (h) Status reports to the client. Final reports in preparation. Technical Report No. 9, Washington State Institute of Technology, entitled "Hydraulic Model Studies for Rocky Reach Hydroelectric Power Project -- Fish Passage Facilities" has been published.
- (2879) HYDRAULICS OF LEVEL IRRIGATION.
 - (b) Laboratory project cooperative with the Department of Agricultural Engineering, Washington State University.
 - (d) Theoretical and experimental.

- (e) Analysis is being developed to define rate of advance and recession of the water front on a level irrigation border taking into account the infiltration. A tilting flume 75 feet long, 3 feet wide and 2 feet deep has been erected. A mechanical apparatus to simulate infiltration is being installed.
- (g) Theoretical and experimental results agree well.
- (h) "Water Surface Configuration and Velocity of Advance in Hydraulic Laboratory Tests."
- (3192) ADVANCE OF A SHALLOW LIQUID FRONT DOWN A DRY CHANNEL.
- (b) National Science Foundation Grant.
- (d) Theoretical and experimental; basic research.
- (e) Mathematical equations are being analyzed. Experiments will be conducted in a tilting flume to supplement and verify the theoretical approach. A glass-lined tilting flume has been completed and tests with oil are underway.
- (g) Theoretical analysis is confirmed by results from "Hydraulics of Level Irrigation" described above.
- (h) "The Terminal Shape of a Shallow Liquid Front" presented at Phoenix convention A.S.C.E., April 1961, and published in Journal of Hydraulics Division, A.S.C.E.
- (3534) WELLS HYDRO-COMBINE.
- (b) Bechtel Corporation.
- (d) Experimental; design.
- (e) A 1:23.3 scale model of a section of the spillway-powerunit hydro-combine structure has been built and is under test. These tests are for the purpose of evaluating various hydraulic characteristics of an unusual design for hydro-electric developments, specifically spillway capacity, downstream river bed erosion, fish passage, structural vibration, subatmospheric pressure regions, and the effect of spillway flow on the turbine operation. A model turbine and dynamometer has been installed to measure any differences in power output with and without spillway flow. Pressure cells are being used for dynamic pressure measurements which in turn will be analyzed to study impressed vibrations.
- (3848) CALIBRATION OF FLOW METERING FLUMES.
- (b) Agricultural Research Service, Boise, Idaho.
- (d) Experimental; design.
- (e) Metering flumes are being placed on several streams within an experimental watershed in southern Idaho. Desirable shapes, location of head measuring taps, orientation and elevation of invert of these flumes are being investigated by hydraulic model. The effect of flow rate, upstream and downstream topography, and sediment deposition will be considered. A 1:30 scale model and an auxiliary model at a scale of 1:9 have been built, upon which the design was investigated and subsequent revisions recommended. Calibration of one metering device has been completed by use of the models and the actual flume is now under construction. Tests on other metering flumes will be started during the year.
- (h) Status reports to client.
- (3849) NONCIRCULAR CONDUITS.
- (b) Laboratory project supported in part by Nat. Acad. Sciences grant to Dr. Jamil Malaika.
- (d) Theoretical and experimental; basic research.
- (e) The effect of cross-sectional shape on friction loss in the fully turbulent regions is being investigated by studying the flow in circular, square, elliptical, rectangular, and rhombic conduits. All experimental tests are now completed and data are being analyzed and processed for a report.
- (4242) ROUND BUTTE.
- (b) Portland General Electric Company.
- (d) Experimental; design.
- (e) A 1:42 model of a tunnel spillway has been built and tested. Features studied during these tests were the entrance conditions from the pool through an ogee spillway into the 21-foot tunnel, a vertical bend in the tunnel and the 1,400-foot, horizontal length of the tunnel and a flip bucket at the downstream end of the tunnel.
- (g) The tunnel spillway passed the design discharge without completely filling the 21-foot diameter conduit. Minor modifications to the flip bucket and transition between the ogee spillway and the circular conduit were necessary before the spillway operated satisfactorily at all discharges.
- (h) "Hydraulic Model Studies of the Round Butte Tunnel Spillway," Washington State Inst. of Technology Bulletin No. 256.
- (4243) UMPQUA RIVER ESTUARY MODEL.
- (b) U. S. Department of Health, Education and Welfare.
- (d) Experimental.
- (e) A distorted model of the Umpqua River Estuary including the confluence of the Umpqua and Smith Rivers is under construction. The vertical scale of this model is 1:100 and the horizontal scale is 1:3000. A mechanical six-component tide computer with a plunger type generator produces the tides in a tank simulating the Pacific Ocean. Factors to be considered during the study include river flow, tides, and salinity. The purposes of the model are to (1) determine whether a model of this size will be adequate to investigate pollution problems and (2) study a particular pollution question on the Umpqua River.
- (4244) SULTAN DAM NO. 1.
- (b) R. W. Beck and Associates.
- (d) Experimental; design.
- (e) A 1:50 scale model of the Sultan Dam No. 1 is being tested to evaluate the various schemes for construction of this thin arch dam and spillway. Included in this study is a scheme for building the dam in two stages so that two spillways are required.
- (4245) HYDRODYNAMIC INVESTIGATION.
- (b) Laboratory project.
- (d) Theoretical and experimental; applied research.
- (e) Tests are being made on nappe deflectors to obtain design data and permit selection of this type of energy dissipator prior to experimental testing in connection with a specific application. This type of energy dissipator has been used on Rocky Reach and Noxon Rapids dams and is being considered for use at Chungju dam.
- (h) Paper will be prepared when all the tests are completed and the data has been analyzed.
- (4246) ROUND BUTTE TRIFURCATION MODEL.
- (b) Portland General Electric Company.
- (d) Experimental; design.
- (e) A 1:23.7 scale model of a power penstock trifurcation is under construction. Tests will determine whether the proposed design will be subject to undue structural vibrations. The total dynamic head loss through the trifurcation will also be determined.
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- UNIVERSITY OF WASHINGTON, Fisheries Research Inst.
- (3535) EFFECTS OF LOGGING ON PRODUCTIVITY OF PINK SALMON STREAMS IN ALASKA.

- (b) Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Juneau, Alaska, is contracting agency. Co-operating agency is Alaska Forest Research Center, U. S. Forest Service, Juneau, Alaska.
- (c) Prof. Donald E. Bevan, Research Associate Professor, Fisheries Research Institute, University of Washington, Seattle 5, Wash.
- (d) Experimental, theoretical, and field investigation; basic and applied research, including master's and doctoral thesis research.
- (e) To identify environmental factors causing mortality of pink salmon embryos; (2) to gain a more complete understanding of inter-relationships among spawning behavior, physical and biological attributes of the stream and spawning bed, and mortality of embryos; (3) to determine how the quality of the spawning bed environment as it pertains to growth, development, and mortality of embryos is affected by logging; and (4) to determine criteria for the improvement of natural spawning areas to increase production of juvenile salmon. Included among active routine studies are hydrological conditions, intragravel water quality, spawning bed quality, and channel debris evaluation. Included among active basic studies are composition and source of suspended sediment and bed load, relationship between gravel composition and permeability, exchange between surface and intragravel water, and sources of intragravel water.
- (g) Methods have been developed for routine field measurement of dissolved oxygen content of intragravel water, gravel composition, and mortality of salmon embryos. Gravel shift has been identified as an important natural cause of embryonic mortality. A theoretical model of factors controlling interchange between stream and intragravel water has been proposed and tested qualitatively.
- (h) "A Method of Estimating Mortality of Pink Salmon Eggs and Larvae," by William J. McNeill. Contribution No. 119, 28 pp. manuscript, (in press).
 "New Methods for Sampling Bottom Fauna and Periphyton in Salmon Spawning Gravels," by Warren Harry Ahnell, Master's Thesis, Univ. of Washington, Seattle, 83 pp, 1961.
 "Fluid Flow in the Open-Surfaced Porous Bed," by Walter G. Vaux, Master's Thesis, Univ. of Minnesota, St. Paul, Minnesota, 85 pp., plus appendixes, 1961.
 "Frequency of Digging Movements of Female Pink Salmon Before and After Egg Deposition," by William L. Sheridan, Contribution No. 68, Animal Behavior, Vol. 8, No. 3-4, pp. 228-230, 1960.
 "Temperature Relationships in a Pink Salmon Stream in Alaska," by William L. Sheridan, Contribution No. 76, Ecology, Vol. 42, No. 1, pp. 91 - 98, 1961.
 "Relation of Stream Temperatures to Timing of Pink Salmon Escapements in Southeast Alaska," by William L. Sheridan, Contribution No. 93, Submitted to MacMillan Lectureship Series, University of British Columbia, 23 pp. manuscript, (in press).
- (4247) IMPROVEMENT OF SALMON SPAWNING AREAS ON INDIAN CREEK AND HARRIS RIVER, ALASKA.
- (b) U. S. Forest Service, Juneau, Alaska, Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Juneau, Alaska.
- (c) Prof. Donald E. Bevan, Research Associate Professor, Fisheries Research Inst., Univ. of Washington, Seattle 5, Washington.
- (d) Experimental, theoretical, and field investigation basic and applied research, including thesis research.
- (e) Artificial spawning areas have been constructed on the Indian Creek and Harris River on Prince of Wales Island within the Tongass National Forest, Alaska. The project is to test the general hydraulic considerations associated with the design of improved pink salmon spawning areas in natural streams. Objectives of the research program are to test the design of artificial improvements to salmon spawning grounds. The problem is to determine if we can provide, at reasonable cost, small areas of stable permeable gravel in which low water flow of stream will be concentrated. The evaluation of artificially constructed channels will provide information of the detailed requirements of spawning fish as well as the requirements of eggs and larvae. Further information will be obtained on movement of bed material as no stream flow regulation is provided.
 (g) Data currently being analyzed.
 (h) "Hydraulic Design and Construction Details of Salmon Spawning Channel Improvement Areas on Indian Creek and Harris River," by R. E. Nece, Circular No. 145, Fisheries Research Institute, 8 pp. Mimeo, July 1961.
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- UNIVERSITY OF WASHINGTON, Charles W. Harris
 Hydraulics Laboratory.
- (3852) A STUDY OF THE USE OF GUIDE VANES IN A 90 DEGREE UNSYMMETRICAL MITERED BEND.
- (b) Laboratory project.
- (c) Prof. H. S. Strausser, 201 More Hall, Univ. of Washington, Seattle 5, Washington.
- (d) Experimental and theoretical investigation for M. S. thesis.
- (e) To study the geometry of guide vanes necessary to produce uniform velocity distribution downstream from a 90 degree mitered bend where entrance and exit areas are different. Open channel approach; conduit discharge.
- (f) Completed.
- (g) A configuration of a fixed geometry of guide vane with variable angle of incidence was found which would produce quite uniform velocity distributions in the exit conduit downstream from bend.
- (h) Unpublished M.S. Thesis available on loan from correspondent, H. S. Strausser.
- (3853) FLOW THROUGH AN ARRAY OF CYLINDERS.
- (b) Laboratory project.
- (c) Prof. Ronald E. Nece, Dept. of Civil Engrg., Univ. of Washington, Seattle 5, Washington.
- (d) Experimental; basic research.
- (e) Hydrodynamic forces are to be determined on one of a row of circular cylinders. Cylinder spacing and orientation of the single row with respect to a uniform approach flow are to be varied.
- (g) Proximity effects upon drag coefficients have been determined for two cylinder row orientations for the case of laminar boundary layers on the cylinders.
- (h) One M.S. Thesis completed (available on loan)
- (4248) BYPASS ENTRANCE STUDY, DOWNSTREAM MIGRANT SEPARATION FACILITIES, MAYFIELD FISH FACILITIES.
- (b) Department of Public Utilities, Major Projects Division, City of Tacoma, Wash.
- (c) Prof. H. S. Strausser, Prof. R. E. Nece, Dept. of Civil Engineering, Univ. of Wash., Seattle 5, Washington.
- (d) Experimental investigation; design verification and/or correction.
- (e) A two-dimensional model study of an unsymmetrical 90 degree mitered, vaned elbow in a vertical plane and with a free-surface approach flow was conducted to produce a vane configuration yielding a uniform velocity distribution over the entire flow depth at the elbow inlet.
- (f) Completed.
- (g) A suitable, simple guide vane arrangement was

- found which yielded satisfactory velocity profiles, for the single bend geometry studied, over a range of approach flow depths.
- (h) One M. S. thesis completed (available on loan). Report to sponsoring agency; contact this agency for copy of report.
- (4249) A COMPARISON OF MITERED AND STREAMLINED PIPE TEES.
- (b) Alaskan Copper and Brass Company.
- (c) Mr. W. Rosen, Sr., 3223 Sixth Avenue South, Seattle, Washington or Prof. G. R. Thiers, Univ. of Washington, Civil Engineering Dept., Seattle, Washington.
- (d) Field investigation; operation.
- (e) Determination of loss coefficients for 2-inch welded "Tee" pipe fittings; (1) mitered, (2) streamlined.
- (f) Completed.
- (g) (1) $C_L = 1.6$, (2) $C_L = 0.8$.
- (4250) CALIBRATION OF TOTALIZING FLOW METER.
- (b) Kenson Engineering Co., 10602 N. E. 26th, Bellevue, Washington.
- (c) Prof. G. R. Thiers, Dept. of Civil Engineering, University of Washington, Seattle 5, Washington.
- (d) Field investigation; operation.
- (e) Calibration of totalizing flow meter for 2-inch pipe. (Screw propeller-proximity pick-up counts revolutions of propeller).
- (f) Completed.
- (g) Total volume passing through meter found proportional to number of turns of propeller.
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- UNIVERSITY OF WISCONSIN, Hydraulics Laboratory.
- (149) THE EFFECT OF SUBMERGENCE ON FLOW CHARACTERISTICS OF HYDRAULIC STRUCTURES.
- (b) Laboratory project.
- (c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
- (d) Theoretical and experimental; basic and applied research for M.S. degree.
- (e) The effects of submergence on discharge of large circular thin-plate weirs and orifices and broad-crested weirs are being studied.
- (g) General correlation equations have been developed for all thin-plate weirs, Parshall Flumes, and one type of Ogee spillway.
- (956) ENERGY LOSS IN LIQUID FLOW IN PIPES AND FITTINGS UNDER HIGH PRESSURE.
- (b) Laboratory project in cooperation with the Ladish Company, Cudahy, Wisconsin, and the Wisconsin Alumni Research Foundation.
- (c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
- (d) Theoretical and experimental; applied research and design for B.S., M.S. and Ph.D. theses.
- (e) Energy loss measurements in straight pipes and fittings have been completed on sizes 1/4 inch to 2 inches. Pressure range 0-2500 psi, temperature range 60 to 120 degrees F. Reynolds number range 50 to 150,000.
- (f) Suspended.
- (g) If viscosity, density, and temperature relations are known, the standard pipe friction theory applies at high pressures. The fitting loss constants for laminar flow are about 3 times those for turbulent flow when $N_R = 2000$. The loss gradually reduces to zero at $N_R = 150$.
- (1181) VORTEX FLOW FROM HORIZONTAL THIN-PLATE ORIFICES.
- (b) Wisconsin Alumni Research Foundation and J. C. Stevens, Consulting Engineer, Portland, Oregon.
- (c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
- (d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.
- (e) The effects of vorticity on orifice discharge were studied over a wide range of vorticity, head, and orifice size.
- (g) A new parameter, the vortex number, was developed as the ratio of inertial and centrifugal forces. A general correlation procedure was also developed for estimating discharge rates through orifices with varying degrees of vorticity.
- (3539) THE EFFECT OF BOUNDARY ROUGHNESS AND CONFIGURATION ON TURBULENCE LEVEL AND VELOCITY DISTRIBUTION.
- (b) Wisconsin Alumni Research Foundation.
- (c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
- (d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.
- (e) New instrumentation has been developed to measure turbulence levels in pipes and ducts. The effects of boundary roughnesses on the decay of extra turbulence caused by a variety of boundary configurations is being studied.
- (3540) MODEL STUDIES OF PUMP INLET STRUCTURES.
- (b) Wisconsin Alumni Research Foundation in cooperation with the Government of West Bengal, India.
- (c) Prof. J. R. Villemonte, Hydraulics Lab., University of Wisconsin, Madison 6, Wis.
- (d) Experimental; design for M.S. thesis.
- (e) A 1/16-scale model of the inlet structure for one of four axial flow pumps at the Uttarbhadg Pumping Station (Sonarpur, India) has been made. Studies of inlet flow patterns and pressure coefficients for a wide variety of flow situations are being made for the purpose of reducing the cavitation threshold.
- (3541) HYDRAULIC CHARACTERISTICS OF CIRCULAR SEDIMENTATION BASINS.
- (b) National Institutes of Health, Washington, D. C.
- (c) Prof. G. A. Rohlich and Prof. J. R. Villemonte, Hydraulics Laboratory, University of Wisconsin, Madison 6, Wisconsin.
- (d) Experimental; basic research and design for M.S. and Ph.D. theses.
- (e) A versatile, transparent, 6-foot diameter cylindrical basin has been constructed which will permit model studies at depth to diameter ratios of 0.67 to 0.083. Flow patterns and dispersion characteristics will be observed over a wide range of overflow rates. New instrumentation for measuring small velocities and dispersion functions are being developed.
- (3854) REACTION JET INLET FOR OIL-WATER SEPARATORS.
- (b) The American Petroleum Inst.
- (c) Prof. G. A. Rohlich and Prof. J. R. Villemonte, Hydraulics Laboratory, Univ. of Wisconsin, Madison 6, Wisconsin.
- (d) Experimental; basic research and design for master's and doctoral theses.
- (e) A transparent basin 5 feet wide, 10 feet long and 3 feet deep has been constructed. Investigations will be made using various sizes and spacings of the stengel reaction jets at the entrance to the basin to determine the effects of jet inflow on the hydraulic characteristics.
- (4251) A STUDY OF CHANNEL THALWEG PROFILES ABOVE AND BELOW GULLY CONTROL STRUCTURES.
- (b) U.S. Department of Agriculture, Agricultural Research Service.
- (c) Dr. Arno T. Lenz, Chairman, Dept. of Civil

- Engineering, University of Wisconsin, Madison 6, Wisconsin.
- (d) Field investigations and analytical studies. Part will be used for doctoral thesis.
- (e) Field surveys of 80 gully control structures in Southwestern Wisconsin have been completed. The data from these surveys are being analyzed in an attempt to develop procedures for estimating quantitatively the dynamic changes in channel profiles which occur when a gully control or sediment detention structure is built.
- (4252) FLOW OF A DENSITY STRATIFIED FLUID.
- (b) Wisconsin Alumni Research Foundation.
- (c) Prof. P. L. Monkmeier, Hydraulics Laboratory, University of Wisconsin, Madison 6, Wis.
- (d) Theoretical and experimental; basic research for Ph.D. thesis.
- (e) Characteristics of compressible and incompressible density stratified fluids, both viscous and inviscid, steady and unsteady, are being investigated. Research on internal gravity waves is included. A flume for studying density stratified fluids is planned.
- (g) Linearized equations for steady, ideal, compressible, stratified flow in atmospheres with various density distributions have been developed.
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- WOODS HOLE OCEANOGRAPHIC INSTITUTION.
- (4253) MODEL EXPERIMENTAL STUDIES OF OCEANIC AND ATMOSPHERIC CIRCULATIONS.
- (b) Woods Hole Oceanographic Institution.
- (c) Mr. Alan J. Faller, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Experimental and theoretical; basic research.
- (e) Creation of experimental models and analogues to obtain more fundamental understanding of the circulation of fluids in rotating systems with particular application to geophysical fluid circulations.
- (g) An experimental analogy with hurricane spiral bands in which banded structures in a vortex system were obtained in a laboratory circulation. An analogy was drawn between the spiral bands observed in the experiments and the cloud bands observed in hurricane systems, and it was proposed that the instability of the boundary-layer flow which was the source of the banded structure in the experiments was the mechanism for the banded cloud patterns of hurricanes as well.
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- WORCESTER POLYTECHNIC INSTITUTE, Alden Hydraulic Laboratory.
- Inquiries concerning the following projects should be addressed to Professor Leslie J. Hooper, Director, Alden Hydraulic Laboratory, Worcester Polytechnic Institute, Worcester 9, Mass.
- (1963) METER CALIBRATION.
- (b) Foxboro, Company, Foxboro, Mass.
- (d) Experimental, for design.
- (e) Calibration of various sizes of 1" to 36" diameter magnetic flow tubes.
- (f) Tests in progress.
- (3544) SWING CHECK VALVES.
- (b) Atwood and Morrill Co., Salem, Mass.
- (d) Experimental; for design.
- (e) Tests including determination of pressure drop, pressure surge, and disc orientation were conducted on a 10" valve.
- (f) Tests completed.
- (3545) HYDRAULIC CYCLONE.
- (b) Bird Machine Co., South Walpole, Mass.
- (d) Experimental; for design.
- (e) Evaluation of the percentage break up of the flow between accepts and rejects in a cyclone type separator were determined. The flow pattern in various sections of the machine were studied in detail.
- (f) Test in progress.
- (3857) METER CALIBRATION.
- (b) General Controls Co., Foster Div., Warwick, Rhode Island.
- (d) Experimental, for design.
- (e) Laboratory calibration of various meters from 2" to 24" diameter.
- (f) Tests in progress.
- (3859) METER CALIBRATION.
- (b) B-I-F Industries Inc., Providence, R. I.
- (d) Experimental; for design.
- (e) Calibration of open flow nozzles and venturi meters up to 48" in diameter.
- (f) Tests in progress.
- (3860) SMITH MOUNTAIN HYDROELECTRIC DEVELOPMENT.
- (b) Ebasco Services, Inc., New York, N. Y.
- (d) Experimental; for design.
- (e) A 1/60 scale model of a section of the Roanoke River was duplicated including the proposed arch dam, spillways, and chutes, powerhouse and penstocks. Studies included spillway performance, energy dissipation in river below spillway chutes, powerhouse, penstock and tailrace flow conditions. The second stage of the river diversion was modeled and tested. Finally pumping tests on the pump-turbine units were also duplicated to study tailrace flows under these conditions.
- (f) Tests completed.
- (3861) SMITH MOUNTAIN HYDROELECTRIC DEVELOPMENT.
- (b) Sollitt Construction Co., South Bend, Ind.
- (d) Experimental; for design.
- (e) A 1/60 scale model of the river bed at the construction site was constructed. The model included various structures necessary for stream diversion during the first phase of construction. Details studied on the model included upstream and downstream cofferdams, retaining walls, bed excavation and location of construction bridge piers.
- (f) Tests completed.
- (4254) PLUG TYPE VALVES.
- (b) Rockwell Manufacturing Co., Pittsburgh, Pa.
- (d) Experimental; for design.
- (e) Tests were performed to determine pressure drop for a range of flows on 3 valves (8", 16" and 36" dia). In addition a measurement of torque required to open and close at each of the flows was made.
- (f) Tests completed.
- (4255) METER CALIBRATION.
- (b) Penn Meter Company, Philadelphia, Pa.
- (d) Experimental; for design.
- (e) Calibration of open flow nozzles and flow tubes from 2" to 48" in diameter.
- (f) Tests in progress.
- (4256) METER CALIBRATION.
- (b) Narda Ultrasonics Corp, Syosset, N. Y.
- (d) Experimental; for design.
- (e) Calibration of 14" diameter ultrasonic flow meter.
- (f) Tests completed.
- (4257) LEESVILLE HYDROELECTRIC DEVELOPMENT.
- (b) Ebasco Services, Inc., New York, N. Y.
- (d) Experimental; for design.
- (e) A 1/50 scale model of a section of the

Roanoke River including the gravity dam, 4 gated spillway section and 2 unit powerhouse along with the tailrace and stilling basin was constructed to study flow characteristics of the completed development. In addition the model was arranged so that the diversion scheme could also be reproduced and operated.

(f) Tests completed.

(4258) CALIMA HYDROELECTRIC DEVELOPMENT

(b) Tippetts, Abbett, McCarthy, Stratton.

(d) Experimental; for design.

(e) A 1/40 scale model of the spillway system on the Calima river in Columbia including a section of the reservoir and upstream face of the dam and incorporating the glory-hole spillway were constructed in an elevated steel tank. The river bed from the top of the dam to well below the spillway tunnel exit was modeled in concrete on the basin floor. Transparent plastic transitions and tunnel sections were used to model the tunnel between the spillway and the outlet. Spillway performance and flow in the tunnels and at the outlet were studied during the test program.

(f) Tests in progress.

(4259) CAMPBELL ESTATE HARBOR.

(b) Tippetts, Abbett, McCarthy, Stratton.

(d) Experimental; for design.

(e) A 1/50 scale model of a section of ocean and coastline adjacent to the site were modeled along with an entrance channel and the harbor basin itself. A pneumatically operated wave generator was provided to produce a variety of wave conditions at the entrance channel. Studies involved testing

a number of different designs aimed at minimizing the wave action in the basin and in the channel.

(f) Tests completed.

(4260) VELOCITY PROFILE EFFECTS.

(b) Laboratory project.

(d) Experimental; applied research.

(e) A number of different pressure differential type flow meters were tested using a variety of conditions upstream thus studying and measuring the velocity profile upstream and in the meter. The effect of these velocity profiles on the discharge coefficient was determined.

(f) Completed.

(g) The results of the study are reported in a paper submitted to the American Society of Mechanical Engineers for consideration on 15 December 1961.

(h) "Velocity Profile Effects on the Discharge Coefficient of Pressure Differential Meters," by Mr. A. G. Ferron.

(4261) METER CALIBRATION.

(b) Gulton Industries Inc., Metuchen, N.J.

(d) Experimental; for design.

(e) Calibration of 16" diameter ultrasonic flowmeter.

(f) Tests completed.

(4262) METER CALIBRATION.

(b) Potter Aeronautical Corporation, Union, New Jersey.

(d) Experimental; for design.

(e) Calibration of various sizes from 6" to 16" turbine type flow meters.

(f) Tests completed.

CORN BELT BRANCH, University of Minnesota, St. Paul,
Minn., Dr. C. A. Van Doren, Branch Chief.

(1723) THE HYDRAULICS OF CONSERVATION STRUCTURES.

See St. Anthony Falls Hydraulic Laboratory
Projects Nos. 111, 1168, 1929, and 2386.
See also U. S. Department of Agriculture,
Agricultural Research Service, Soil and
Water Conservation Research Div., Southern
Plains Branch, Project No. 4335, and Illinois
State Water Survey Division Project No. 1865.

- (b) Cooperative with the Minnesota Agricultural
Experiment Station, the St. Anthony Falls
Hydraulic Laboratory, and the Illinois State
Water Survey.
- (c) Mr. Fred W. Blaisdell, Hydraulic Engineer,
St. Anthony Falls Hydraulic Laboratory,
3rd Ave. S. E., at Mississippi River,
Minneapolis, Minnesota.
- (d) Experimental; applied research for develop-
ment and design.
- (e) Research dealing with the design, con-
struction, and testing of structures for
conserving and controlling soil and water
are carried out. Studies during the past
year have been concerned with the two-way
drop inlet for closed conduit spillways.
The width of this drop inlet is equal to
the barrel diameter. Its length varies.
Water flows only over the two sides. The
end walls support a horizontal plate over
the drop inlet which acts as an anti-vortex
device. The overhang of the plate supports
a trash guard. Tests are conducted using
both water and air as the model fluid to
determine the performance, loss coefficients,
and pressure coefficients for the drop inlet.
Cooperation with and co-ordination of the
tests at the Stillwater, Oklahoma, Outdoor
Hydraulic Laboratory and the Illinois State
Water Survey is maintained.
- (g) If the anti-vortex plate is too low,
undesirable orifice flow will control the
discharge. If the anti-vortex plate is too
high, harmful vortices will form under the
plate. Rules for determining acceptable
plate heights have been determined. The
overhang of the plate must be greater than
a certain minimum to insure satisfactory
performance. The action of the two-way
drop inlet is that of a self-regulating
siphon. The tests using air agree with the
results obtained from the water tests and
are much easier to perform. Air is used as
the model fluid only for the condition of
full conduit flow.

(4263) A STUDY OF CHANNEL THALWEG PROFILES ABOVE
AND BELOW GULLY CONTROL STRUCTURES.

See University of Wisconsin Civil Engineering
Project No. (4251).

- (b) Laboratory project, cooperative with the
Department of Civil Engineering, University
of Wisconsin, and the Wisconsin Agricultural
Experiment Station.
- (c) Mr. D. A. Woolhiser, Hydraulic Engineer,
3230 University Avenue, Madison 5, Wisconsin.
- (d) Field investigations and analytical studies.
Part will be used for doctoral thesis.
- (e) Field surveys of 80 gully control structures,
built in the 1930's, in southwestern
Wisconsin have been completed. The data from
these surveys are being analyzed in an
attempt to develop procedures for estimating
quantitatively the dynamic changes in channel
profiles which occur when a gully control or
sediment detention structure is built.
- (g) No set pattern of aggradation or degradation
in the channel below gully-control structures
has yet been established but there is a
tendency for initial channel scour to revert

toward aggradation. Changes which do occur
are related to conditions at the site such
as tributary contributions of coarse sediment
vegetative encroachment, exposure of rock
controls and interference by farming
operations. Analyses of data are continuing.

(4264) HYDROLOGIC STUDIES ON AGRICULTURAL
WATERSHEDS IN WISCONSIN.

- (b) Laboratory project, cooperative with the
Wisconsin Agricultural Experiment Station
and the Wisconsin Valley Improvement Co.
- (c) Mr. K. E. Saxton, Hydraulic Engineer, 3230
University Avenue, Madison, Wisconsin.
- (d) Field investigation and office analysis.
- (e) Various records of runoff, ground water,
precipitation and climatic factors, soil
moisture, land use, and agricultural
conditions and practices are maintained for
22 agricultural watersheds ranging in size
from 2.7 to 11,000 acres in the vicinity of
LaCrosse, Fennimore, Colby and at other
locations in Wisconsin. Analyses are made
to evaluate the factors affecting flood
flows, hydrograph characteristics, and the
yield of stream flow.
- (h) "Predicting Storm Runoff on Small Experi-
mental Watersheds," by N. E. Minshall,
Jour. of the Hydraulics Div., Proc. Am. Soc.
Civil Engineers, Vol. 86, No. HY 8, Aug.
1960.
"Effect of Cover and Soils on Runoff," by
N. E. Minshall, Jour. Soil and Water Conser-
vation. (In press)

(4265) PRECIPITATION CHARACTERISTICS INFLUENCING
RUNOFF FROM AGRICULTURAL WATERSHEDS ON THE
UNGLACIATED ALLEGHENY PLATEAU.

- (b) Laboratory project, cooperative with Ohio
Agricultural Experiment Station.
- (c) Mr. L. L. Harrold, Investigations Leader,
Agricultural Research Service, Coshocton,
Ohio.
- (d) Field investigation and office analysis.
- (e) To develop methods of characterizing
watershed precipitation related to runoff
rates and volumes and to evaluate "normalcy"
of sample periods.
- (g) Records of dense network of rain gages are
being analyzed to determine network
specifications for characterizing rainfall
for runoff rates and volumes. Shielded and
tilted catchment surfaces of rain gages
have been installed in the field along with
wind recording apparatus for studying the
effect of wind on the rain gage catch and
how the latter evaluates the rainfall on
sloping land surfaces of a single aspect.
- (h) "The Influence of Land Use and Treatment on
the Hydrology of Small Watersheds at
Coshocton, Ohio," by L. L. Harrold, D. L.
Brakensiek, J. L. McGuinness, C. R. Amerman,
and F. R. Dreibelbis, USDA Tech. B. 1256,
December 1961.

(4266) SURFACE RUNOFF AND INTERFLOW STUDIES IN THE
UNGLACIATED ALLEGHENY PLATEAU.

- (b) Laboratory project, cooperative with the
Ohio Agricultural Experiment Station.
- (c) Mr. L. L. Harrold, Supervisory Hydraulic
Engineer, ARS, Coshocton, Ohio.
- (d) Field investigation and office analysis.
- (e) To evaluate the factors affecting the
volume of storm surface runoff and interflow
from various combinations of upland watershed
soil, cover, and treatment, and to study the
basic factors affecting the hydrograph of
these flows under various soil-cover
combinations.
- (g) Work is continuing on these studies. Storm
flow totals from all unit source watersheds
along with specific watershed and climatic
parameters have been assembled for all the
major storm runoff periods of record.
Computer analysis of these data is being
made to test for parameter significance.

(4267) STUDIES OF RUNOFF FROM COMPLEX WATERSHEDS IN THE UNGLACIATED ALLEGHENY PLATEAU.

- (b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
- (c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
- (d) Field investigation and office analysis.
- (e) To determine how flows from incremental areas combine to produce hydrographs of stream flow on larger complex watersheds; determine the effects of climate and watershed characteristics on rates and amounts of runoff; and develop methods for predicting the magnitude and frequency of flows from ungaged watersheds.
- (g) Work is continuing on these studies. Preliminary analysis showed that the summation of flow from incremental areas accounted for, at the best, only 70 percent of the storm flow measured for the larger complex watershed. Base flow was at a minimum. Interflow studies are being made to evaluate the magnitude and timing of this quick return flow as a factor in flood stream flow. Geologic investigations of aquifers contributing to stream flow are included in the study of the effects of watershed characteristics and management of stream flow. Their effect is an important factor, as runoff volumes increase rapidly with watershed size up to areas of 1,000 acres.
- (h) "Evaluation of the Hydrologic Effect of a Watershed Plantation," by L. L. Harrold, Proc. Soc. of Amer. Foresters, Wash. D. C. 1960.
"The Influence of Land Use and Treatment on the Hydrology of Small Watersheds at Coshocton, Ohio," by L. L. Harrold, D. L. Brakensiek, J. L. McGuinness, C. R. Amerman, and F. R. Dreibelbis, USDA Tech. Bul. 1256, December 1961.
"Hydrologic Relationships for Watershed Studies in Ohio," by L. L. Harrold, Soil Conservation, S.C.S. Vol. 26, No. 9, April 1961.

(4268) STUDIES IN SUBSURFACE HYDROLOGY IN THE UNGLACIATED ALLEGHENY PLATEAU.

- (b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
- (c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
- (d) Field investigation and office analysis.
- (e) To evaluate ground-water and interflow contributions to stream discharge of agriculture watersheds and the recharge to aquifers under various watershed and climatic conditions.
- (g) Work is continuing on geologic mapping for identifying and evaluating aquifer flow to stream discharge. Catchment areas of these contributing aquifers is being mapped. Studies of interflow have been started on the upland watersheds to help account for that storm flow at the complex watershed runoff gages not measured as upland surface runoff.
- (h) "Hydrologic Nature of Streamflow on Small Agricultural Watersheds," by J. L. McGuinness, L. L. Harrold, and C. R. Amerman, Proc. Am. Soc. C.E., Vol. 87, HY-1, January 1961.

(4269) MOISTURE REGIMES OF SOILS IN THE UNGLACIATED ALLEGHENY PLATEAU.

- (b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
- (c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
- (d) Field investigation and office analysis.
- (e) To maintain the soil moisture inventory of agricultural watersheds; to evaluate the effect thereon of soil, land use, and climate; to develop methods of estimating soil moisture quantities under various land use and climatic conditions; and to determine the influence of frozen soil and frost

- structure on water movement.
- (g) Nuclear soil-moisture equipment is now providing good data on soil moisture down to 90-inch depths. They show material variations in moisture within a small watershed. Presently, methods of evaluating watershed soil moisture are being studied. Effect of vegetation of different rooting depths on soil moisture is being evaluated. Deep-rooted crops extract moisture to depths unaffected by shallow-rooted crops. In dry seasons, the former consumes more water than the latter, resulting in less percolation to ground water reservoirs. Lysimeters, 8 feet deep and 1/500 acre area of undisturbed soil record weight changes and percolation.
- (h) "Evaluation of Agricultural Hydrology by Monolith Lysimeters," by L. L. Harrold and F. R. Dreibelbis, USDA Tech. Bul. 1179, August 1958.
"Soil Moisture Measurements with the Neutron Method Supplement Weighing Lysimeters," by J. L. McGuinness, F. R. Dreibelbis, and L. L. Harrold. Proc. SSSA, Vol. 25, No. 5, pp. 339-342. September 1961.
"Comparison of the Soil Moisture Regimen in Lysimeters with that on Adjacent Watersheds," by F. R. Dreibelbis, U.S.D.A. ARS-47, 1961.

(4270) CHARACTERISTICS OF FLOW IN IRRIGATION FURROWS.

- (b) Soil and Water Conservation Research Div., Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Missouri Agricultural Experiment Station.
- (c) Mr. John F. Thornton, Agricultural Engineer, 204 Agricultural Engineering Building, Columbia, Missouri.
- (d) Experimental and field investigations, both basic and applied.
- (e) The purpose of the investigation is to determine the effects of rate of water application, intake rate, slope, shape and roughness on the advance rates under furrow irrigation. Develop engineering techniques that will provide maximum effective control and management of irrigation water.
- (g) The work is continuing on the basic hydraulic aspects of flow in irrigation furrows to contribute to better understanding of furrow irrigation and the ultimate achievement of more efficient use of water.
- (h) "Summary of Hydraulics of Furrow Irrigation Studies in Missouri" by John F. Thornton. Proc. ARS-SCS Workshop on Hydraulics of Surface Irrigation, pp. 63-66, October 1960.

(4271) PLASTIC-LINED MOLE DRAIN STUDIES.

- (b) Soil and Water Conservation Research Div., Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Ohio Experiment Station.
- (c) Mr. James L. Fouss, Agricultural Engineer, Agricultural Engineering Dept., Ohio State University, Columbus, Ohio.
- (d) Experimental and field investigations, both basic and applied.
- (e) The purpose of these investigations is to improve plastic mole drainage techniques and test the effectiveness of other surface drainage systems. Tile, mole and other sub-surface drainage systems are developed and their effectiveness determined.
- (g) The work is continuing on improving plastic mole drainage techniques and the effectiveness of other surface drainage systems.
- (h) "Plastic-Lined Mole Drains," by James L. Fouss. For presentation at the 1961 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 12-15, 1961.

(4273) SURFACE AND SUBSURFACE DRAINAGE.

- (b) Soil and Water Conservation Research Div., Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the

- (c) Minnesota Agricultural Experiment Station. Mr. Lee Hermsmeier, Agricultural Engineer, North Central Soil Conservation Field Station, Morris, Minnesota.
- (d) Experimental and field investigations, both basic and applied.
- (e) The purpose of these investigations is to develop engineering techniques that will provide maximum effective control and management of water. Techniques are developed for managing surface water flow through land forming and surface drainage systems. Tile, mole and other subsurface drainage systems are developed and their effectiveness determined.
- (g) Work is continuing on land forming and the development of improved surface drainage systems, the effectiveness of field diversions, improved plastic mole drainage techniques and effectiveness of other subsurface drainage systems.
- (h) "Land Forming--A New Water Management Practice," by Lee F. Hermsmeier and Curtis L. Larson. Minnesota Farm and Home Science, Vol. 17, No. 1, pp. 8-9, October 1959.
- (4274) DEVELOPMENT AND REFINEMENT OF METHODS FOR PREDICTING FIELD RUNOFF AND SOIL LOSS.
- (b) Laboratory project, cooperative with various State Agricultural Experiment Stations throughout the U. S.
- (c) Mr. W. H. Wischmeier, Analytical Statistician, ARS Runoff and Erosion Data Laboratory, Agricultural Engineering Dept., Purdue University, Lafayette, Indiana.
- (d) Data analyses, applied research.
- (e) The purpose of the work is to develop improved techniques for determining the optimum soil and water conservation practices for any specific farm field and to provide the research data needed for localized applications of the techniques in farm planning. Basic runoff, soil loss and related data assembled at the laboratory from 45 research locations in 23 states are analyzed to determine effects of rainstorm characteristics, soil, topography, cover, management practices and various factor interactions on soil and water losses from farm fields. The relationships and evaluations are combined into equations for estimating erosion losses from specific fields under numerous feasible farming plans and conservation practices. The various alternative systems which would control erosion can then be evaluated economically to determine the optimum system.
- (g) Efforts toward greater accuracy in empirical soil-loss equations was continued with special emphases on effects of soil properties, rainstorm characteristics and factor interactions. An iso-erodent map was developed from Weather Bureau rainfall intensity data. The map shows the rainfall-erosion index value for any location in the 37 states east of the Rockies. Graphs depicting the monthly distribution of erosive rainfall in various climatic areas were completed. Work on derivation of an empirical runoff equation was begun.
- (h) "A Universal Soil-Loss Estimating Equation to Guide Conservation Farm Planning," by W. H. Wischmeier and D. D. Smith, Tran. 7th Congress of International Soil Sci. Soc., Vol. 1, paper VI. 2, 1961.
- "Rainfall Erosion," by D. D. Smith and W. H. Wischmeier, Vol. 14 of Advances in Agronomy, Academic Press, Inc., New York, 1961.
- "Distribution of Rainfall Erosion Potential in the U. S.," by W. H. Wischmeier, 1961. (In press) Mimeo copy avail. as paper #61-228, Amer. Soc. Agr. Engineer.
- "Storms and Conservation Practices," W. H. Wischmeier, 1961. (In press) Mimeo copies avail. from Soil Cons. Soc. of Amer., Des Moines 14, Iowa.
- (4275) THE MECHANICS OF EROSION BY RAINFALL AND RUNOFF.
- (b) Agricultural Research Service cooperating with the Minnesota, Indiana and Iowa Agricultural Experiment Stations.
- (c) Mr. W. H. Wischmeier, Analytical Statistician, Agricultural Engineering Dept., Purdue Univ., Lafayette, Indiana.
- (d) Experimental; laboratory investigations, basic research.
- (e) The purpose of these studies is to obtain fundamental information on the mechanics of rainfall, runoff and erosion. C. K. Mutchler at Morris, Minnesota is investigating raindrop splash patterns as affected by various degrees of soil softness, surface irregularity and surface detention. L. D. Meyer at Lafayette, Indiana is investigating the mechanics of soil particle movement under thin films of water. Primary and interaction effects of particle size, slope, and velocity and depth of flow will be studied. W. C. Moldenhauer at Ames, Iowa is investigating the effects of rainfall on the surface conditions, erodibility and physical characteristics of various soils. Crusting, soil movement and particle-size sorting will be studied.
- (4276) IMPROVED PRACTICES FOR CONTROL OF RUNOFF AND EROSION.
- (b) Agricultural Research Service cooperating with Purdue Agricultural Experiment Station.
- (c) Mr. J. V. Mannering, Soil Scientist, Agronomy Dept., Purdue University, Lafayette, Indiana.
- (d) Experimental; field investigations, applied research.
- (e) The purpose of these studies is to determine the effects of soil properties, slope characteristics, type and extent of canopy cover, quantity and management of crop residues, seedbed and tillage practices, and various factor interactions on infiltration and erosion. Replicated tests are conducted on selected plots on Purdue-owned and privately-owned farms in Indiana and adjoining states under simulated rainfall. Soil samples and runoff samples are analyzed in the laboratory.
- (g) Studies during the past year included (1) erosion-control evaluation of several minimum-tillage practices for corn, (2) effect of various quantities of applied straw mulch on runoff and erosion, (3) effect of rotation meadows on runoff and erosion from successive years of corn following the meadow, and (4) residual erosion-control effectiveness of meadows on erodibility of fallow soils.
- (h) "Soil and Water Conservation Research with the Rainulator," by L. D. Meyer and J. V. Mannering, Trans. 7th Congress of International Soil Science Society, Vol. 1, Paper VI. 7, 1961.
- "Minimum Tillage for Corn: Its Effect on Infiltration and Erosion," by L. D. Meyer and J. V. Mannering, Ag. Engineering 42 (2) 72-75, 86, 87, 1960.
- "The Effects of Different Methods of Cornstalk Residue Management on Runoff and Erosion," by J. V. Mannering and L. D. Meyer, Soil Sci. Soc. Amer. Proc. 25 (6), November-December 1961.
- "The Effects of Various Rates of Mulch Applied to a Fallow Soil on Infiltration and Erosion," by J. V. Mannering and L. D. Meyer, Agronomy Abstracts, 1961.
- (4277) SOIL ERODIBILITY.
- (b) Agricultural Research Service cooperating with Agricultural Experiment Stations in Indiana, Minnesota and South Dakota.
- (c) Mr. W. H. Wischmeier, Analytical Statistician, Agricultural Engineering Dept., Purdue University, Lafayette, Indiana.
- (d) Experimental; laboratory and field

- investigations, basic and applied.
- (e) The purpose of this study is to identify and evaluate the soil properties and profile characteristics which influence erodibility of the soil and to combine these in a multiple regression equation. The equation would serve to evaluate the soil-erodibility factor of soils for use in the universal erosion equation. Infiltration and soil-loss measurements will be made on a broad range of soils under identical simulated rainstorms applied with the Indiana and Minnesota Rainulators.
- (4278) RAINFALL ENERGY AND SOIL EROSION RELATIONSHIPS.
- (b) Agricultural Research Service cooperating with Illinois Agricultural Experiment Station.
- (c) Mr. L. C. Johnson, Soil Scientist, 276 Davenport Hall, University of Illinois, Urbana, Illinois.
- (d) Experimental; field investigation.
- (e) The purposes of this study are (1) to obtain an experimental check on the computed rainfall intensity-kinetic energy relationship, and (2) to study the physical phenomena and changes associated with the infiltration of natural rain into soils. Three replications of fallow and continuous corn are under both hydrological and meteorological measurements.
- (4279) RUNOFF AND EROSION STUDIES IN IOWA.
- (b) Agricultural Research Service cooperating with Agricultural Experiment Station.
- (c) Dr. W. C. Moldenhauer, Soil Scientist, 225 Agronomy Bldg., Iowa State University, Ames, Iowa.
- (d) Experimental; field investigations, applied research.
- (e) To evaluate soil and crop management practices in relation to water management and erosion control on the major Iowa soils. Runoff, soil loss and related data are being taken on 65 fractional-acre plots under natural rainfall.
- (g) Consistent good management of abundant crop residues proved very effective in reducing runoff and erosion from these silt loams. Contour surface planting on 12% slope reduced erosion losses more than 50% on an annual basis, but its effectiveness decreased with increased storm erosivity. Contour listing was more effective than contour surface planting and did not lose its effectiveness under the most severe early summer thunderstorms.
- (h) "Soil and Water Losses and Infiltration Rates on Ida Silt Loam as Influenced by Cropping Systems, Tillage Practices and Rainfall Characteristics," by W. C. Moldenhauer and W. H. Wischmeier, Soil Sci. Soc. Amer. Proc. 24: 409-413, 1960.
- (4280) RUNOFF AND EROSION STUDIES ON THE SLOPING LANDS OF WISCONSIN.
- (b) Agricultural Research Service cooperating with Wisconsin Agricultural Experiment Station.
- (c) Mr. O. E. Hays, Soil Scientist, P. O. Box 872, LaCrosse, Wisconsin.
- (d) Experimental; field investigations, applied research.
- (e) The purpose of these studies is to obtain information on the effects of the basic factors (climatic, topographic, soil, cover and management) on runoff and soil loss. Hydrological and meteorological measurements are made on 66 fractional-acre plots and two small watersheds to evaluate the following with respect to runoff and erosion: (1) chemical treatments and interseeding methods for pasture renovation, (2) practices required to control erosion in corn following corn on steep slopes, (3) strip cropping, (4) different types of seedbed for corn and small grain, (5) keeping corn clean with the use of weedicides, and (6) effect of degree of land slope.
- (g) On corn after hay, wheeltrack planting and seedbed preparation with a field cultivator each reduced runoff by 50% and soil loss by about 75%. Corn stover mulch in corn following corn gave excellent control of runoff and erosion of 16% slope, Fayette soil. Interseeding legumes in wide-row corn established meadows which produced yields comparable to those established in small grain and greatly reduced total rotation soil loss.
- (h) "New Tillage Methods Reduce Erosion and Runoff," by O. E. Hays, Journal of Soil and Water Conservation 16: 172-175, 1961. "Methods of Controlling Erosion and Runoff in Continuous Corn on Steeply Sloping Land," by R. E. Taylor and O. E. Hays, Agronomy Abstracts 1961, page 41.
- (4281) RUNOFF AND EROSION STUDIES ON THE MIDWEST CLAYPANS.
- (b) Agricultural Research Service cooperating with Missouri Agricultural Experiment Station.
- (c) Mr. J. F. Thornton, Agricultural Engineering Dept., University of Missouri, Columbia, Missouri.
- (d) Experimental; field investigation, applied research.
- (e) To evaluate effects of soil treatments, tillage practices and supplemental irrigation on runoff and erosion from about 10 million acres of Midwest Claypans. Runoff, soil loss and concomitant variables are measured on a series of fractional-acre plots and small watersheds under natural rainfall. Fertilization adequate to produce high crop yields and large quantities of plant residues greatly reduced the formerly serious soil and water losses from sloping claypan soils. Seedbed preparation by sub tillage, which left shredded cornstalks on or near the surface, significantly reduced erosion losses even from very high intensity storms.
- (h) "Runoff and Erosion Losses from Mexico Silt Loam in Relation to Fertilization and Other Management Practices," by F. D. Whitaker, V. C. Jamison and J. F. Thornton, Soil Sci. Soc. Amer. Proc. 25: 401-403, 1961.
- (4282) RUNOFF AND EROSION STUDIES IN MINNESOTA AND EASTERN SOUTH DAKOTA.
- (b) Agricultural Research Service cooperating with State Experiment Stations.
- (c) Mr. C. K. Mutchler, Agricultural Engineer, North Central Soil Conservation Field Station, Morris, Minnesota.
- (d) Experimental; field investigations, applied research.
- (e) The purpose of these studies is to characterize runoff and erosion on the Barnes silty clay loam and Poinsett soils. Measurements are obtained under both natural rain and simulated rainfall on fractional-acre field plots. Numerous vegetative covers and crop sequences common to the area are being investigated with respect to their effects on runoff and erosion. Soil and water losses from thaw and snow melt will also be measured.
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- U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.
- NORTHEAST BRANCH, Plant Industry Station, Beltsville, Maryland, Mr. W. W. Pate Branch Chief.
- (3089) EXPERIMENTAL STUDY OF EROSION IN CURVED CHANNELS.
- Cooperative with Mass. Inst. of Tech. See

(3867) IRRIGATION AND DRAINAGE FACILITIES.

- (b) Laboratory project, cooperative with Virginia Agricultural Experiment Station.
- (c) Mr. J. Nick Jones, Agricultural Engineer, Agricultural Engineering Dept., Virginia Polytechnic Inst., Blacksburg, Virginia.
- (d) Field investigations.
- (e) The irrigation study seeks to determine the effect of selected irrigation procedures on quality and yield of tobacco on Cecil soils of the Piedmont plateau. Landforming to permit use of machinery, facilitate irrigation, and provide for disposal of surface water, are major objectives of the drainage studies. Both meteorological and hydrological measurements are made. Landforming studies were conducted on Coastal Plains soils in eastern Virginia, and on Piedmont Valley soils.
- (f) The irrigation studies were initiated in 1961 and first records will be taken in 1962. Landforming studies for disposal of excess water in the Coastal Plains are essentially completed.
- (g) Landforming studies in the Coastal Plains during one of the wettest crop seasons on record showed that, on soils formed to a slope of 0.15 percent, runoff water may be disposed of in well-graded channels between ridged crop rows for at least 600 feet without causing decreased crop yields. Data from another location indicated that row lengths might be as much as 1200 feet.
- (h) "Control of Surface Water by Landforming," by T. W. Edminster, ISSS Proceedings, (In Press).

(4283) A STUDY OF FLOOD FLOWS AND THEIR EFFECTS ON STREAM CHANNELS.

- (b) Cooperative project with Soil Conservation Service and Cornell University.
- (c) Mr. R. P. Apmann, Hydraulic Engineer, 21 South Grove Street, East Aurora, N. Y.
- (d) Experimental field investigations.
- (e) To determine the important streamflow qualities which materially affect the intensity of attack upon the stream channel periphery material and the variation throughout the flow boundary of forces destructive to the channel periphery material. Investigations are conducted on selected natural reaches of Buffalo Creek and tributaries in the vicinity of East Aurora, New York and on the Pequest River in Warren County, New Jersey.

(4284) DEVELOPMENT AND EVALUATION OF METHODS FOR CHANNEL STABILIZATION.

- (b) Cooperative project with Soil Conservation Service and Cornell University.
- (c) Mr. R. P. Apmann, Hydraulic Engineer, 21 South Grove Street, East Aurora, New York.
- (d) Experimental field investigations.
- (e) To develop economical methods for streambank stabilization through observation and measurement of the effectiveness of various vegetal and structural measures over a range in streamflow conditions and for various channel geometry. Principal investigations are conducted on Buffalo Creek and tributaries in the vicinity of East Aurora, New York.

(4285) CHANNEL HYDRAULICS AND FLOOD ROUTING IN STEEP MOUNTAIN STREAMS.

- (b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service.
- (c) Mr. M. L. Johnson, Hydraulic Engineer, Route 2, Danville, Vermont.
- (d) Experimental field investigations.
- (e) Studies on a 1.5-mile reach of the Sleepers

River channel involving determination of: travel speed of controlled waves of different volumes; profiles of natural and controlled waves of different volumes; practical field methods of measuring the friction slope of mountain channels; comparisons between results obtained with flood routing formulas and observed flood wave data; and the relationship between channel efficiency, flow duration curves, and watershed morphology.

(4286) INFLUENCE OF SNOW AND FROZEN SOIL ON RUNOFF.

- (b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service.
- (c) Mr. M. L. Johnson, Hydraulic Engineer, Route 2, Danville, Vermont.
- (d) Experimental field investigations.
- (e) This study on the 43-square mile Sleepers River watershed is concerned with the factors influencing the accumulation and melting of snow; the relationship of frozen soil to runoff; and the development of methods for predicting runoff associated with snow melt. Data are collected and analyzed from snow courses, precipitation gages, temperature records, heat budgets, soil moisture and frost measurements and snow melt in conjunction with streamflow records at nine stations in the subdivided watershed.

(4287) PRECIPITATION PATTERNS AND CHARACTERISTICS.

- (b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service.
- (c) Mr. E. T. Engman, Hydraulic Engineer, Route 2, Danville, Vermont.
- (d) Experimental field investigations.
- (e) The purpose of this study is to develop a method for calculating average precipitation on the 43-square mile Sleepers River watershed and its subdivisions in relation to elevation, storm source and direction; to study the behavior of summer convective storms in the northeast; and to provide information on rainfall depth-area-duration in relation to point rainfall in this part of the northeast.

(4288) INFLUENCE OF SOIL AND LAND USE ON STREAMFLOW FROM AGRICULTURAL WATERSHEDS.

- (b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service.
- (c) Mr. G. H. Comer, Hydraulic Engineer, Route 2, Danville, Vermont.
- (d) Experimental field investigations.
- (e) Investigations of the influence of land use, climatic factors, and physical characteristics such as soils, geology, and topography upon runoff rates and water yields from the 43-square mile Sleepers River watershed and its important subdivisions to derive relationships for predicting the hydrologic performance of ungaged watersheds in the other parts of the physiographic area.

(4289) SUBSURFACE CONTRIBUTIONS TO STREAMFLOW IN SLEEPERS RIVER WATERSHED.

- (b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service.
- (c) Mr. G. H. Comer, Hydraulic Engineer, Route 2, Danville, Vermont.
- (d) Experimental field investigations.
- (e) Development of procedures for separating streamflow into components of surface runoff and contributions from underlying aquifers in the Sleepers River Watershed with consideration of the effects of vegetation and

evapo-transpiration on water yields.

(4290) GROUNDWATER ACCRETION AND MOVEMENT IN RELATION TO WATERSHED CHARACTERISTICS.

- (b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service.
- (c) Mr. E. T. Engman, Hydraulic Engineer, Route 2, Danville, Vermont.
- (d) Experimental field investigations.
- (e) To develop information on ground water accretion and movement as affected by land use, soils, geology, and topography; and to develop methods for predicting ground water accretion and movement in relation to the physical, hydraulic, and meteorological characteristics of the 43-square mile Sleepers River watershed.

(4291) INFLUENCE OF LAND USE ON THE HYDROLOGY OF AGRICULTURAL WATERSHEDS IN VIRGINIA.

- (b) Cooperative project with the Virginia Agricultural Expt. Sta., Virginia Polytechnic Inst., and the Soil Conservation Service.
- (c) Mr. J. B. Burford, Hydraulic Engineer, Agricultural Engineering Department, Virginia Polytechnic Inst., Blacksburg, Va.
- (d) Experimental field investigations.
- (e) To provide additional knowledge concerning the disposition of precipitation in agricultural watersheds, and to develop procedures based upon watershed characteristics, climatic factors, and various land use practices for the prediction of flood peaks and seasonal and annual water yields in three physiographic areas. Hydrologic, geologic, soils, plant cover and cultural data are being obtained on 4 unit source watersheds varying in size from 3.5 to 19.3 acres in the Appalachian Valleys and Ridges and on 10 complex watersheds from 182 to 3,054 acres in the Appalachian Valleys and Ridges, Blue Ridge Mountains, and the Piedmont Plateau.
- (g) The instrumentation for the 10 complex watersheds was completed recently. Hydrologic data on all watersheds are being tabulated, summarized, and analyzed as the data are being accumulated. A comparison of two outstanding events emphasizes the importance of the relationship of land use and cover conditions to flood peak discharges. The one-year frequency storm of June 1942 produced a 7 percent greater flood peak discharge from a straight-row cultivated unit source watershed than the 100-year frequency storm of August 1960 produced from the same area under strip cropped conditions.

(4292) HYDROLOGIC EFFECTS OF CHISELING SHALLOW SHALE SOIL IN WEST VIRGINIA APPALACHIAN VALLEYS AND RIDGES.

- (b) Cooperative with West Virginia Agricultural Experiment Station and the Soil Conservation Service.
- (c) Mr. V. O. Shanholtz, Hydraulic Engineer, 409 Grant Avenue, Morgantown, West Virginia.
- (d) Field investigations.
- (e) The purpose of this study is to determine the effect of chiseling shallow shale subsoil upon rainfall-runoff relationships on small watersheds. Measurements for calibration of four 10-acre watersheds have been underway since the spring of 1958. Two of the watersheds will be treated following the calibration period.

(4293) MECHANICS OF EROSION.

- (b) Laboratory project, cooperative with New Hampshire Agricultural Experiment Station.
- (c) Mr. R. S. Palmer, Agricultural Engineer, University of New Hampshire, Agricultural Engineering Dept., Durham, New Hampshire.
- (d) Field and laboratory studies, both basic

- (e) and applied, for development and design. The purpose of these investigations is:
 - (1) To determine the impact forces of various size water drops in relation to the nature of the soil surface, depth of water layer, and soil type; and, (2) to investigate soil and water problems involved in gully formation and to develop more effective control measures.
- (g) A laboratory apparatus has been designed for producing raindrops of varying sizes and frequencies. Gully development along river terraces in New England is confined to a period of about one week during the spring thaw. Gully development apparently is most serious with a combination of shallow frost penetration and heavy runoff from snow melt. Installing dikes along the terrace edge appears to be an effective control measure.
- (h) "Gully Development on a New Hampshire Farm," by R. S. Palmer, New Hampshire Progress Report, Vol. 7, No. 1, pp. 10-12, 1961. "An Apparatus for Forming Water Drops," by R. S. Palmer, USDA Production Research Report, (In Press). "Water Drops for Simulating Rainfall," by R. S. Palmer, New Hampshire Experiment Station Progress Report, (In Press). "Gully Control in the Connecticut River Valley," by R. S. Palmer, Agricultural Engineering, (In Press). "Water Jet Break-Up from Stainless Steel Tubes," by R. S. Palmer, Agricultural Engineering, (In Press).

(4294) ERODIBILITY OF SOILS IN THE NORTHEAST.

- (b) Laboratory project, cooperative with Maine Agricultural Experiment Station.
- (c) Mr. Eliot Epstein, Soil Scientist, Univ. of Maine, Orono, Maine.
- (d) Laboratory and field investigations both basic and applied for development and design.
- (e) The purpose of these investigations is to obtain fundamental information on the erodibility of Northeast soils and to determine the interrelations of climate, cover (including rock fragments), runoff, and soil loss.
- (g) Removal of rocks that interfere with sorting of potatoes by mechanical harvesters resulted in increased runoff and soil erosion and decreased crop yields during the first year of the study. Installations were completed on a laboratory rainfall simulator where basic studies on soil erodibility are being initiated.
- (h) "Soil Moisture Survey of Some Representative Main Soil Types," by E. Epstein, W. J. Grant, and J. S. Hardesty, USDA ARS-57, (In Press).

(4295) TILLAGE PRACTICES AND DIVERSION TERRACES FOR WATER AND EROSION CONTROL.

- (b) Laboratory project, cooperative with the New York Agricultural Experiment Station, and the Soil Conservation Service.
- (c) Mr. George R. Free, Soil Scientist, Bailey Hall, Cornell University, Ithaca, New York.
- (d) Field investigations.
- (e) The purpose of these investigations is to determine the inter-relation of tillage, topography, climate, runoff and soil loss, and to evaluate the effectiveness of diversion terraces for controlling surface and subsurface flow.
- (g) Work is continuing on the effectiveness of conventional, mulch and minimum tillage for corn on runoff and erosion from slopes of different steepness and length and on the effect of diversion terraces on surface soil moisture during critical crop growth stages for several sloping soils having seepage problems.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL

NORTHERN PLAINS BRANCH, P. O. Box 758, Fort Collins, Colo., Dr. C. E. Evans, Branch Chief.

(2902) DEVELOPMENT AND IMPROVEMENT OF WATER MEASURING DEVICES.

- (b) Laboratory project, cooperative with the Colorado Agricultural Experiment Station.
- (c) Mr. A. R. Robinson, Supervising Agricultural Engineer, Hydraulic Laboratory, Colorado State University, Fort Collins, Colorado.
- (d) Experimental laboratory research, field investigation; applied research operation and development.
- (e) This project has the general objective of developing and improving devices and techniques for the measurement of irrigation water. Specific objectives now in progress or recently completed are: (1) Design, evaluation and calibration of trapezoidal measuring flumes; (2) Re-evaluation of the submergence effects of Parshall measuring flumes and effect of variable angle of convergence; (3) Evaluation of vane-type flow meters.
- (g) Results from present tests indicate that the procedure for determining flow rates from submerged Parshall flumes can be simplified and made more accurate. Present indications are that trapezoidal measuring flumes have considerable merit over those of the Parshall type. Tests are continuing on different designs of these flumes. Tests on the vane-type flow meters indicate a probable accuracy under field operation of plus or minus 5 percent.
- (h) "Study of the Cox Flow Meter (Modified Hall Pitot Tube)," by A. R. Robinson, Report to Board of Water Commissioners, City and County of Denver, Colorado, January 1961. "Study of the Beaver Creek Measuring Flumes," by A. R. Robinson, report to Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, February 1961. "Evaluation Study of the Pendvane Flowmeter," by A. R. Robinson, prepared through the cooperation of the Applied Research Company, the Colorado Experiment Station and the Agricultural Research Service, September 1961.

(3217) HYDROLOGIC STUDIES OF GROUND WATER IN THE RED RIVER VALLEY OF NORTH DAKOTA.

- (b) Laboratory project, cooperative with North Dakota Agricultural Experiment Station.
- (c) Mr. Leo C. Benz, Agricultural Engineer, P. O. Box 806, Grand Forks, North Dakota.
- (d) Field investigation; applied research.
- (e) The project covers a rectangular area of approximately 200 square miles. This area is gridded with observation wells and piezometer batteries to evaluate artesian conditions, water table gradients and fluctuations, and ground water quality. The purpose of the project is to conserve soil and water on approximately 400,000 acres of salt-affected soils in the Red River Valley of North Dakota.
- (g) The data indicate that rainfall is a major contributor to high water tables. Piezometer batteries show upward gradients but pressures are dissipated at depths of 10 to 30 feet. Salt sources are the deep artesian aquifers.
- (h) "Jetting Equipment and Techniques used in a Drainage and Salinity Study," by R. H. Mickelson, L. C. Benz, C. W. Carlson and F. M. Sandoval. Submitted for publication in Agricultural Engineering. "Groundwater Investigations in a Saline Area of the Red River Valley North Dakota," by L. C. Benz, R. H. Mickelson, F. M. Sandoval and C. W. Carlson, Journal of Geophysical Research, 66(8):2435-2443, August 1961.

- (b) Laboratory project, cooperative with the Colorado Agricultural Experiment Station.
- (c) Mr. E. Gordon Kruse, Agricultural Engineer, Hydraulic Laboratory, Colorado State Univ., Fort Collins, Colorado.
- (d) Experimental and field investigations; basic and applied, portions will be used for master's and doctoral theses.
- (e) This study is an experimental investigation utilizing a tilting flume in which a small channel 60-feet long is formed by natural soil which is fixed in position against movement by chemical spray. A variety of roughness forms can be created on the bed. A range of channel slope and flow depth is used. Channel shape is a variable.
- (g) An equation was developed relating Chezy's resistance coefficient to the standard deviation of the bed roughness in the longitudinal direction and the Reynold's number. Although there is a clear relationship, the standard deviation is inadequate to fully characterize the bed roughness, and some additional geometrical characterization is still needed. Turbulence has been shown to develop in the shallow flows at very low Reynold's numbers and on the other hand, complete turbulence was not developed in the channel at Reynold's number in excess of 7,000.
- (h) "Hydraulics of Subcritical Flow in Small, Rough Channels," by E. G. Kruse. Chapter in USDA ARS 41-43, October 1960.

(4297) COOPERATIVE WATER YIELD PROCEDURES STUDY.

- (b) Laboratory project, cooperative with Soil Conservation Service, USDA, and the Bureau of Reclamation, USDI.
- (c) Mr. A. L. Sharp, Supervisory Hydraulic Engineer, Rm. 505, Rudge and Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
- (d) Office analyses, applied research.
- (e) To develop and test methods for use by field engineers to evaluate the downstream effects of upstream conservation use and treatment of land on water yields of creeks and rivers. The project is one purely of analytic hydrology. The project uses available hydrologic and other data wherever it is available. It secures no new hydrologic data such as streamflow data, climatic data, or land-treatment data. The project is nearing completion.
- (g) To date it has been demonstrated that it cannot be proved statistically significantly that there are downstream effects on streamflow of upstream conservation treatment and use of land, although it is axiomatic that in subhumid to arid areas such effects must exist. A rational method of evaluating such effects has been developed and tested. The method will be published in a final report of the study due late in 1962.
- (h) Abstract "Problems Involved in Determining the Effects of Land Use and Treatment on Water Yields," by A. L. Sharp, A. E. Gibbs, and W. J. Owen. Presented to AGU Meeting, Washington, D. C., May 5-8, 1958. Discussion of "Factors Affecting Evaporation from Plants and Soils," by C. B. Tanner. Jour. Soil and Water Conserv. 14 (2):77-78, March 1959. "Two-Year Progress Report -- Cooperative Water Yield Procedures Study," by A. L. Sharp, W. J. Owen, and A. E. Gibbs. July 1959 (Processed). "Application of the Multiple Regression Approach in Evaluating Parameters Affecting Water Yields of River Basins," by A. L. Sharp, A. E. Gibbs, W. J. Owen, and B. Harris Jour. Geophys. Research 65:4, 1273-1286, April 1960. "A Comparison of Methods for Estimating

- Precipitation on Watersheds," by A. L. Sharp, W. J. Owen, and A. E. Gibbs. Jour. Geophy. Research, (In Press).
- "An Improved Statistical Model for Evaluating Parameters Affecting Water Yields of River Basins," by A. L. Sharp, A. E. Gibbs, W. J. Owen, and B. Harris. Jour Geophys. Research 66:10, 3319-3328, October 1961.
- "Transmission Losses in River Valley Alluviums," by A. L. Sharp and K. E. Saxton. Presented at SCS Hydrologists Workshop, Reno, Nevada, October 4, 1961, (Processed).
- (4298) COMPARISONS OF RATES AND AMOUNTS OF RUNOFF FROM SMALL SINGLE-COVER WATERSHEDS.
- (b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.
 - (c) Mr. J. A. Allis, Supervisory Hydraulic Engineer, P. O. Box 741, Hastings, Nebraska.
 - (d) Field investigations -- applied research.
 - (e) To determine differences in runoff from 4-acre watersheds in various crops -- meadow, pasture, cultivated, and eroded cultivated land seeded to grass. Replicated watersheds are instrumented with recording raingages, flumes and stage recorders. Six cultivated watersheds are in a wheat-sorghum-fallow rotation. Mulch (subsurface) tillage is practiced. Effects of the different crops and land uses on storm runoff rates and amounts are determined by analyzing hydrographs and histograms. Seasonal, annual, and longtime effects are determined by analyzing precipitation and runoff data.
 - (g) Considerable differences in runoff have been observed. Runoff from native meadowland is very low, that from pastureland is intermediate, and runoff from cultivated land is highest.
 - (h) "Runoff from Small Watersheds," by J. A. Allis and L. L. Kelly. Soil Conservation Magazine, March 1958.
- (4299) RUNOFF AND HYDROGRAPH CHARACTERISTICS OF LARGE MIXED-USE WATERSHEDS.
- (b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.
 - (c) Mr. J. A. Allis, Supervisory Hydraulic Engineer, P. O. Box 741, Hastings, Nebraska.
 - (d) Field investigations -- applied research.
 - (e) To determine characteristics of runoff from large mixed-use watersheds as related to, or affected by, precipitation, channel storage, transmission losses to valley alluvium, time of concentration, stream gradient, and watershed size. Three watersheds, in mixed use, 481,2086 and 3490 acres in size, are instrumented with rain gages, weirs, and stage recorders for observing precipitation and runoff. Transmission losses to valley alluviums are estimated by use of gaged outflow and estimates of inflow from unit source areas of tributary land. These latter estimates are based on gaged rainfall on and runoff from small 4-acre single-use source area watersheds. Hydrographs and histograms are analyzed to obtain watershed retention (infiltration) rates and hydrograph characteristics.
 - (g) Runoff absorption by valley alluviums amounts to 25 to 40 percent of unit source area water yield. Peak rates of runoff are lowered, and hydrographs are flattened, by streams of low gradient that meander through broad, flat valleys.
 - (h) "Rates of Runoff for the Design of Conservation Structures in the Central Great Plains of Nebraska and Kansas," by John A. Allis, Soil Conservation Service, USDA, SCS-TP-69, August 1948.
 - "Comparison of Storm Runoff Volumes from Single-Crop Watersheds and a Larger Mixed-Cover Watershed at Hastings, Nebraska," by John A. Allis, Transactions, American Society of Agricultural Engineers, 1961, (In Press).
 - "Transmission Losses in Loessial Watersheds,"
- by John A. Allis, 1961, (Processed).
- (4300) COMPARISON OF RUNOFF AND SEDIMENT YIELDS FROM CONSERVATION AND CONVENTIONALLY FARMED WATERSHEDS.
- (b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.
 - (c) Mr. J. A. Allis, Supervisory Hydraulic Engineer, P. O. Box 741, Hastings, Nebraska.
 - (d) Field investigations -- applied research.
 - (e) To determine the effects of conservation farming and land use on rates and amounts of runoff and sediment yield. Two 400-odd-acre watersheds, one conventionally farmed and the other conservation farmed, are equipped with recording rain gages, weirs and stage recorders, and sediment samplers, to measure precipitation, runoff, and sediment yields. The two watersheds were operated the same during a calibration period from 1939 to 1947. One was then treated by terracing, contour tillage and seeding eroded cultivated land to grass.
 - (g) Data are now being analyzed.
- (4301) FACTORS AFFECTING RATES AND AMOUNTS OF RUNOFF FROM RANGELAND.
- (b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
 - (c) Mr. A. L. Sharp, Supervisory Hydraulic Engineer, Rm. 505, Rudge & Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
 - (d) Field investigations, applied research.
 - (e) To determine the effects of light, heavy, and moderate grazing and other factors such as precipitation, antecedent soil moisture, soil frost and snow accumulation, on rates and amounts of runoff from fine-textured soils in range in southwestern South Dakota. Replicated plots of about 2 acres each in lightly, moderately, and heavily grazed pastures are instrumented to observe runoff (stage recorders and flumes), rates and amounts of precipitation (recording rain gages), soil moisture, soil temperatures, soil frost and vegetative conditions. The observations are being made on the Branch Experiment Station near Cottonwood, South Dakota.
- (4302) MEDICINE CREEK WATERSHED INVESTIGATIONS.
- (b) Laboratory project, cooperative with the Soil Conservation Service, U. S. Geological Survey, Bureau of Reclamation, and Nebraska Agricultural Experiment Station.
 - (c) Mr. V. I. Dvorak, Hydraulic Engineer, Room 505, Rudge & Guenzel Bldg., 134 South 12th Street, Lincoln 8, Nebraska.
 - (d) Field investigations; compilation and analysis of data.
 - (e) Data from this southwestern Nebraska project are being analyzed for the following purposes: (1) To estimate the long-time runoff and sediment yields from 8 years of observed hydrologic watershed data; (2) to determine if acquired runoff, sediment and channel data will adhere to the existing channel regime equations for six runoff stations; and (3) to compile and prepare a publication indicating what data have been collected as part of the cooperative investigations, and where these data may be found.
 - (g) The long-time sediment yields for the six watersheds have been computed by three different approaches. In each of these methods, the observed runoff and sediment data for 8 years were used for the projection.
 - (h) Final report in preparation.
- (4303) SEDIMENT YIELD AS RELATED TO GULLY AND CHANNEL EROSION.
- (b) Laboratory project, cooperative with the Soil Conservation Service, and Nebraska and Kansas Agricultural Experiment Stations.

- (c) Mr. V. I. Dvorak, Hydraulic Engineer, Rm. 505, Rudge & Guenzel Bldg., 134 S. 12th St., Lincoln 8, Nebraska.
- (d) Field investigations; compilation and analysis of data.
- (e) The objectives of this project are: (1) To determine and relate rates of gully and channel erosion to causal factors; (2) to provide basic data on rates of land loss and land depreciation due to gully erosion; and (3) to develop criteria, based upon hydrologic and physical factors, for estimating quantities of sediment derived from gully erosion.
- (4304) SABETHA LAKE WATERSHED SEDIMENTATION STUDIES.
- (b) Laboratory project, cooperative with the Soil Conservation Service and Kansas Agricultural Experiment Station.
- (c) Mr. V. I. Dvorak, Hydraulic Engineer, Room 505, Rudge & Guenzel Bldg., 134 S. 12th St., Lincoln 8, Nebraska.
- (d) Field investigations and office analysis.
- (e) The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in northeast Kansas; (2) to relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.
- (4305) TRAP EFFICIENCY OF RETARDING-TYPE RESERVOIRS.
- (b) Laboratory project, cooperative with the Soil Conservation Service and the U. S. Geological Survey.
- (c) Mr. H. G. Heinemann, Hydraulic Engineer, Rm. 505, Rudge & Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
- (d) Theoretical and field investigations, and office analyses.
- (e) The trap efficiency of a reservoir is a measure of the effectiveness of the structure in retaining incoming sediment. Structures need to be designed and built with different degrees of trap efficiency, and information is needed so that the influencing parameters can be adjusted to provide the desired trap efficiency. In this study we are endeavoring to (1) collect and study data from retarding-type reservoirs in order to determine those factors that influence trap efficiency, and (2) derive and test methods for predicting the trap efficiency of retarding-type reservoirs.
- (g) About 14 reservoirs have been selected for this study, and various measurements have been made for about 4 years. All reservoirs have been surveyed, and many of them have been surveyed a second time. It is planned that this project will extend over approximately 10 years's time.
- (4306) SEDIMENT DISTRIBUTION IN FLOODWATER RETARDING-TYPE RESERVOIRS.
- (b) Laboratory project, cooperative with the Soil Conservation Service and State Experiment Stations.
- (c) Mr. H. G. Heinemann, Hydraulic Engineer, Rm. 505 Rudge & Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
- (d) Theoretical and field investigations, and office analyses.
- (e) This study was undertaken to improve the design criteria for floodwater retarding-type reservoirs by: (1) determining those factors that influence sediment distribution and evaluating their importance, and (2) deriving and testing methods for predicting the horizontal and/or vertical sediment distribution in floodwater retarding-type reservoirs. This is important in determining the minimum elevation of the principal spillway and the required original capacities of various storage pools.
- (g) During 1959, twenty three reservoirs in the Missouri Basin Loess Hills were studied in detail in regard to sediment distribution. Considerable data were obtained on these reservoirs; and Stage-Capacity, Capacity Replaced by Sediment, and Sediment Distribution Curves were drawn for each. All available data were then analyzed and a procedure developed for determining the elevation to which sediment will accumulate immediately upstream from small floodwater retarding structures. A method was also developed for determining the sediment distribution throughout the original reservoir depth from easily obtained information.
- Data and available information on other reservoirs are being investigated to determine if similar studies can be made for other sections of the country.
- (h) "Sediment Distribution in Small Floodwater-Retarding Reservoirs in the Missouri Basin Loess Hills," by Herman G. Heinemann, USDA, Agricultural Research Service, Report 41-44, 37 pages, February 1961.
- (4307) RESERVOIR FORMULAS AND THE VOLUME-WEIGHT OF RESERVOIR SEDIMENT.
- (b) Laboratory project, cooperative with the Soil Conservation Service and State Agricultural Experiment Stations.
- (c) Mr. H. G. Heinemann, Hydraulic Engineer, Room 505, Rudge & Guenzel Bldg., 134 S. 12th St., Lincoln 8, Nebraska.
- (d) Field and theoretical investigations, and office analyses.
- (e) This project provides criteria for more accurate determination of the sediment yield of watersheds from reservoir survey data. The investigations include: (1) Refinement of procedures and formulas for calculating reservoir capacities and sediment volume from reservoir sedimentation survey data; (2) explanation of variations in the volume-weight of reservoir sediment; (3) recommendations on determination of the total weight of reservoir sediment; and (4) development of procedures for predicting the volume-weight of sediment in a proposed conservation structure.
- (g) Considerable progress has been made on a study of formulas and methods for computing reservoir capacities and sediment volumes. Reservoirs having very good basic detailed surveys are being used to test various methods and formulas. The most consistent and reliable method for obtaining the reservoir capacity is by determining the area between a well-defined stage-area curve and the stage axis. Sediment yield information should always include a volume measurement and its volume-weight. Extensive studies have been started to study the volume-weight of sediment in reservoirs. On Sabetha Reservoir in Kansas, it was found that the volume-weight varies depending on the location of sediment in the reservoir, and also on the percent of clay (2 microns or smaller) present in the sediment.
- (h) "Using the Radioisotope Sediment Densitometer on Sabetha Lake in Kansas," by H. G. Heinemann, USDA, ARS, Soil and Water Conservation Research Division, Research Report No. 343, December 1960.
- (4308) CHARACTERISTICS OF SEDIMENT DEPOSITS IN RANGELAND PONDS AND RESERVOIRS.
- (b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
- (c) Mr. J. W. Neuberger, Hydraulic Engineer, Newell Irrigation and Dryland Field Station, Newell, South Dakota.
- (d) Field investigations, applied research.
- (e) To determine the characteristics of the sediment deposited in rangeland ponds and reservoirs with watersheds of fine-and medium-textured soils, such as

distribution of sediment within the ponds and reservoirs, bulk density of sediment and particle size distribution within the sediment deposits. Watersheds selected for the study are representative of the D-4, D-10 and D-11 soil conservation problem areas of eastern Wyoming and Montana and the western Dakotas. This work is being done by periodically resurveying ponds and reservoirs, and sampling the sediment during each resurvey. Water yield into the ponds is also observed.

- (4309) THE HYDROLOGIC CHARACTERIZATION AND EVALUATION OF PRINCIPAL RANGE SPECIES OF VEGETATION.
- (b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
 - (c) Mr. A. R. Kuhlman, Botanist, Newell Irrigation and Dryland Field Station, Newell, South Dakota.
 - (d) Field and laboratory investigations -- basic research.
 - (e) To develop methods and weights for the hydrologic characterization of principal species of vegetation found in rangeland, in order to evaluate the runoff-producing potentials of various range sites and conditions (based on climax vegetation conditions as determined by soils, climate, aspect, slopes, etc.). Effects of standing vegetation and litter, by species, in protecting the soil surface and affecting infiltration are studied in a rain tower. Effects of root systems of different species on soil aggregation and permeability are investigated in the laboratory. Field tests on pure stands of various species are made to check laboratory results.
- (4310) WATER AND SEDIMENT YIELDS FROM RANGELAND WATERSHEDS.
- (b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
 - (c) Mr. J. W. Neuberger, Hydraulic Engineer, Newell Irrigation and Dryland Field Station, Newell, South Dakota.
 - (d) Field investigations, applied research.
 - (e) To determine the frequency of water yields of various amounts from rangeland watersheds ranging in size from a few acres to 13,000 acres, and gross sediment yields (volumetric) of the same watersheds, as representative of the D-4, D-10, and D-11 soil conservation problem areas in eastern Montana and Wyoming and the western Dakotas. Purposes of these studies are to provide information and methods of estimating water yields from ungaged watersheds and to provide information on which to estimate the probable useful life of ponds and reservoirs in the problem areas. The work is being done by gaging precipitation and water yields, making sedimentation surveys, and securing data on watershed physical, topographic, ecologic and use factors.
 - (g) No definitive results at this time, although early trends indicate most water yield from medium-textured soils of the area result from snowmelt.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

NORTHWEST BRANCH, P. O. Box 2724, Boise, Idaho, Dr. J. S. Robins, Branch Chief.

- (3550) THE EFFECT OF SPRINKLER PATTERN VARIATION ON IRRIGATION EFFICIENCY.
- (b) Laboratory project.
 - (c) Mr. Claude H. Pair, Research Engineer (Irr.),

Agricultural Research Service, P. O. Box 2724, Boise, Idaho.

- (d) Experimental; applied research and design.
 - (e) To determine the effect of sprinkler pattern on field irrigation efficiency and develop a method for calculation of field water application efficiency for a sprinkler system from sprinkler pattern, wind velocity, humidity, temperature, irrigation period, and related factors. Another phase of this project is to test typical sprinkler heads for reproducibility of water distribution pattern.
 - (g) Tests conducted to date indicate that 90 percent of the water applied by the sprinklers to the plots could be accounted for in the catch cans and correction for evaporation using the Frost-Schwalen nomograph. Only 79 percent of the water could be accounted for by the soil sampling method when corrected for consumptive use of plants and evaporation from the sprinkler nozzle to the soil surface using the Frost-Schwalen nomograph.
 - (h) "Sprinkler Irrigation in the U.S.A.," by Claude H. Pair, World Crops, 13:4, 127-130, April 1961, and 13:5, 186-188, May 1961.
- (3552) HYDRAULICS OF SURFACE IRRIGATION.
- (b) Laboratory project.
 - (c) Mr. James A. Bondurant, Agricultural Engineer, Agricultural Research Service, P. O. Box 2724, Boise, Idaho.
 - (d) Experimental; field investigation, basic research.
 - (e) To investigate the factors that influence the advance and recession of water in an irrigation border strip.
 - (h) "Hydraulics of Surface Irrigation," by J. A. Bondurant, in the Proceedings of ARS-SCS Workshop on Hydraulics of Surface Irrigation, ARS 41-43, Oct. 1960.

(3553) MECHANIZATION OF SURFACE IRRIGATION.

- (b) Laboratory project.
- (c) Mr. James A. Bondurant, Agricultural Engr., Agricultural Research Service, P. O. Box 2724, Boise, Idaho.
- (d) Experimental; design and development.
- (e) To develop completely mechanized control systems for surface irrigation.
- (g) Gates which will check the flow of water in a head ditch for a controllable period of time have been developed. These allow a field to be irrigated a portion at a time. When the flow of water into the head ditch is stopped, these gates automatically reset themselves and are ready for the next irrigation. Automatic gates for pipeline systems are also being developed.
- (h) "Mechanization of Surface Irrigation," by J. A. Bondurant, Crops and Soils, V. 14 No. 1, p. 23, Oct. 1961.
- "Automatic Gates for Surface Irrigation," by J. A. Bondurant and A. S. Humpherys, Agricultural Research, V. 10 No. 4, Oct. 1961.
- "Surface Irrigation by Automatic Control," by J. A. Bondurant and A. S. Humpherys, Agricultural Engineering, V. 43 No. 1, p. 20-21, 35, Jan. 1962.

(4311) FLOOD HYDROGRAPHS BY ELECTRONIC ANALOG.

- (b) Laboratory project, cooperative with the University of Idaho.
- (c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho.
- (d) Analytical, basic and applied.
- (e) Further development and adaption of electronic analog methods in the solution of flood routing problems and the prediction of flood hydrographs from agricultural and foothill range watersheds of the northwest.

(4312) WATER YIELD AS INFLUENCED BY CHARACTERISTICS OF NORTHWESTERN RANGE WATERSHEDS.

- (b) Laboratory project, cooperative with the University of Idaho.
- (c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho.
- (d) Analytical.
- (e) Regional analysis of water yield as affected by climatic, topographic, geologic, soil, land use and other characteristics and conditions of rangeland watersheds in the northwest.

(4313) SNOW-MELT HYDROGRAPHS AS INFLUENCED BY CLIMATIC FACTORS AND WATERSHED CHARACTERISTICS.

- (b) Laboratory project, cooperative with the University of Idaho.
- (c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho.
- (d) Analytical, basic and applied.
- (e) To develop improved methods for estimating daily hydrographs of streamflow from mountainous watersheds where the supply is from snow-melt and occasional rain and the evolution of a regional map of snow-melt design coefficients reflecting cover, geology and soils, exposure, elevation, latitude, etc.

(4314) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM NORTHERN SEMI-DESERT WATERSHEDS.

- (b) Laboratory project.
- (c) Mr. J. E. Fletcher, Soil Scientist, P. O. Box 2724, Boise, Idaho.
- (d) Experimental, basic and applied research.
- (e) To determine the pertinent characteristics of precipitation with respect to flood flows, water yield, and sediment movement on rangeland watersheds in the northwest. Studies based upon a network of rain gages at one-mile intervals, snow courses, and other instrumentation on the 98-square mile Reynolds Creek watershed in Owyhee County, Idaho.

(4315) THE DESIGN OF SELF-PROPELLED SPRINKLER SYSTEMS.

- (b) Laboratory project.
- (c) Mr. Claude H. Fair, Research Engineer (Irr.) P. O. Box 2724, Boise, Idaho.
- (d) Experimental, applied research, design.
- (e) Determine water application patterns of self-propelled sprinkler systems. Determine the effect of wind on application patterns of self-propelled sprinkler laterals, and develop method of designing self-propelled sprinkler laterals from theoretical formulas.
- (g) Patterns of self-propelled moving lateral sprinkler systems are being collected for analysis.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

SOUTHERN BRANCH, University of Georgia, Athens, Georgia, Mr. Russell Woodburn, Branch Chief.

(3869) FLUVIAL MORPHOLOGY.

- (b) Laboratory project, cooperative with the Univ. of Miss. and Mississippi State Univ.
- (c) Dr. Neil L. Coleman, Geologist, Sedimentation Laboratory, P. O. Box 158, University, Miss.
- (d) A joint field and laboratory project - basic and applied research.
- (e) Detailed field measurements are made on selected natural water courses and flood plains in the Yazoo River Basin and other selected locations in Mississippi to delineate the variables of stream geometry, bend and bank roughness factors, dune migration, and stream hydraulics in terms of sediment transport characteristics.

Laboratory studies in both 100-foot and 50-foot long flumes are carried out to define significance of various factors under controlled conditions. Acquired data are studied for adherence to existing regime equations, tractive force concepts, resistance coefficients, and bed material transport formulae, and to develop new or improved concepts and relationships.

- (g) The existence of a discontinuity in the stage-discharge relation under certain conditions in sand-bed streams has been established. Changes in channel conveyance efficiency, occasioned by changes in bed configuration have resulted in variances in water discharge of over 100 percent for given water stages. Variations in Manning's roughness coefficient from 0.015 to 0.035 during the course of a storm runoff event have occurred, and for a given water discharge on separate occasions the "n" value has been known to double. Similar variations in the Darcy-Weisbach coefficient have been noted. Froude numbers for floods over plane beds or antidunes in the field are less than Froude numbers computed from comparable flow conditions in the laboratory flumes; this difference in Froude numbers is believed to be partly a function of depth.
- (h) "Lecture Notes on Sedimentation Transportation and Channel Stability," by Vito A. Vanoni, Norman H. Brooks, and John F. Kennedy, Publication No. KHWR-1, California Inst. of Tech., Sept. 1960 (Contract 2206-ARS-61).

(3870) AGGRADATION AND DEGRADATION AS RELATED TO CHANNEL STRUCTURES.

- (b) Laboratory project, cooperative with the Univ. of Miss. and Miss. State University.
- (c) Mr. C. R. Miller, Director, Sedimentation Laboratory, P. O. Box 158, University, Miss.
- (d) Field and laboratory investigations; basic and applied research.
- (e) It is necessary for proper planning and design of agricultural watershed conservation work to have knowledge of the extent of aggradation or degradation that is likely to occur with placement of structures in alluvial channels. Studies of deposition and scour as related to actual structures at various locations in Mississippi, Georgia, Wisconsin and other selected locations to provide the needed field data are underway to develop procedures and criteria useful in predicting channel adjustments with structural installations and accompanying changes in sediment transport and flow pattern.
- (f) Continuing.
- (g) The degree of channel scour and channel erosion rates are being determined in connection with several structural installations in Mississippi. Case histories of over 70 gully control structures in Wisconsin have been established.
- (h) "Case Histories of Gully Control Structures in Southwestern Wisconsin," by David A. Woolhiser and Carl R. Miller, presented at Winter Meeting, ASAE, Chicago, December, 1961. (Reports in preparation).

(3871) LABORATORY STUDIES OF SEDIMENT TRANSPORT.

- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
- (c) Dr. Neil L. Coleman, Geologist, Sedimentation Laboratory, P. O. Box 158, University, Miss.
- (d) Experimental; basic and applied research.
- (e) To better explain, by laboratory flume experiments, the relationships between stream hydraulics and sediment transport which generally occurs in natural channels. Work includes the testing and development of sediment transport equations, means and methods of total transport determination in natural channels, and determination of the

- relationship between the measured transport by use of sediment samplers now in use and the total bed material discharge.
- (g) Flume studies indicate significant errors in sand concentration are possible depending upon relative position of sampler nozzle to a dune front. Studies of various type structures installed in a sand bed channel that will permit total load measurements with minimum upstream and downstream influence suggest the use of a Parshall flume under certain conditions.
- (h) "Effect of Sand Dunes on Sand Transport Determinations by Use of Standard Samplers," by Dr. N. L. Coleman, (In preparation for publication in Ole Miss Engineer.)
 "Dual Channel Stream Monitor," by Earl E. Gray and S. S. Karaki, Colorado State Univ., CER 60 SSK 46, August, 1960 (ARS Contract).
 "Stationary Waves and Antidunes in Alluvial Channels," by John F. Kennedy, Report No. KH-R-2, California Inst. of Tech., January 1961 (ARS Contract).
 "Further Laboratory Studies on the Roughness and Suspended Load of Alluvial Streams," by John F. Kennedy, California Inst. of Tech., Report No. KH-R-3, April 1961 (ARS Contract).
- (4316) HYDRAULICS OF CHANNELS RELATIVE TO CHANNEL STABILITY.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
- (c) Mr. D. A. Parsons, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 158, Univ., Mississippi.
- (d) Experimental, field investigations, applied and basic research.
- (e) Limited at present to the determination of flood flow qualities in selected reaches of Pigeon Roost Creek, Mississippi, and other streams in studies of the resistance to erosion of streambank and bed materials, and streambank vegetation.
- (h) "Effects of Flood Flow on Channel Boundaries," by Donald A. Parsons, Journal of Hydraulics Division, ASCE, Vol. 86, April, 1960.
 "The Distribution of Boundary Shear Stresses in Curved Trapezoidal Channels," by A. T. Ippen, P. A. Drinker, W. R. Jobin, and G. K. Noutsopoulos, MIT Technical Report No. 43, October, 1960 (ARS Contract).
- (4317) PRINCIPLES OF STABLE CHANNELS IN COHESIVE MATERIALS.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
- (c) Dr. Earl H. Grissinger, Soil Scientist, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
- (d) Experimental, applied and basic research.
- (e) Determination of: (1) The reasons for the resisting ability of soil and streambank materials to erosion by flowing water; (2) the kinds of tests needed to measure the resistance; and (3) the quantitative values of the resistance for natural and synthetic materials.
- (h) "A Critique on Stable Channels in Cohesive Materials and a Research Proposal," by Carl R. Miller, ARS Research Report No. 333, August 18, 1960.
- (4318) METHODS OF CHANNEL STABILIZATION.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
- (c) Mr. D. A. Parsons, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
- (d) Experimental, field investigations, applied and basic research.
- (e) Includes: (1) Determination of the speeds of motion and the requisite conditions for beginning of motion of solid particles in fluid flow for various flow, particle quality, and boundary conditions in a laboratory study; (2) field investigations on Pigeon Roost Creek, Mississippi, and other streams of the resisting abilities of bank and bed materials and bank vegetation as determined by measured flood experiences (this study is associated with the one on channel hydraulics); and (3) laboratory and field study of the behavior of non-cohesive sands and silts in a stream channel bank for the conditions of lateral seepage flow to the stream.
- (4319) SEDIMENT YIELDS AND CORRELATION WITH WATERSHED CHARACTERISTICS.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
- (c) Mr. R. F. Piest, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
- (d) Field investigation project - applied research.
- (e) Analyses of hydrologic, hydraulic, land use, soils, and physiographic characteristics of agricultural watersheds, varying in size from a fraction of an acre to 100 sq. mi. are made to establish sediment production, yields, and delivery ratios. Establishment of methodology for determining long-time sediment yields; variation in sediment yield with increasing drainage area, physiography, and complexity; and sediment production and yield prediction procedures are basic objectives.
- (g) Results indicate significant effect of conservation structures on establishment of prediction methods. Data from Pigeon Roost Creek Watershed in Mississippi indicate that water yields are the most significant factor in sediment yields. The physiographic homogeneity and the static conditions of land use patterns throughout the watershed have thus far prevented the determinations of these effects on sediment yields.
- (h) "Runoff and Sediment Yield Characteristics of Some North Mississippi Watersheds," by Robert F. Piest, presented at Winter Meeting of AGU, University of California at Los Angeles, December, 1961.
 "A Note on the Erosive Potential of Rainfall" by Donald A. Parsons, ARS Research Report No. 347, November, 1961.
 "Sediment Concentrations of Three Selected Rises on Pigeon Roost Creek," by Fred W. Long and Andrew J. Bowie, (presented at February, 1962, meeting of Southeastern Section, ASAE, Jacksonville, Florida).
 "Improved Management Reduces Soil and Water Losses," by Coy W. Doty and Farris E. Dendy, presented at Association of Agricultural Workers Annual Meeting, February, 1961, and to be published by Mississippi Farm Research.
- (4320) SEDIMENT ORIGIN AND ROUTING IN A COMPLEX WATERSHED.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
- (c) Dr. L. L. McDowell, Soil Scientist, Sedimentation Lab., P. O. Box 158, University Mississippi.
- (d) Experimental, basic research.
- (e) To develop and apply techniques, including the use of radioisotopes and neutron activation, for the identification of sediment minerals. This information plus an evaluation of selected physical parameters in study watersheds are to be used to develop concepts of soil susceptibility to detachment and transportation.
- (g) Preliminary results are being evaluated. No significant results are available.
- (4321) RESERVOIR SEDIMENTATION.

- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
 - (c) Dr. J. Roger McHenry, Soil Scientist, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
 - (d) Experimental and field investigation for basic research and developmental work.
 - (e) To relate sediment accumulation in reservoirs to sediment yields, runoff, and physical parameters of the watersheds. The nature of the sediment, its origin, mineralogy, chemistry, and biology are studied in relation to distribution and deposition within the reservoir. Nuclear methods are used where applicable.
 - (g) A number of reservoirs have been periodically surveyed for sediment accumulation. Nuclear means of determining in situ densities have been employed.
 - (h) "Determination of densities of reservoir sediments in situ with a gamma probe," by J. Roger McHenry, ARS Research Report ARS 41-53 (in press).
- (4322) DEVELOPMENT OF METHODS FOR UTILIZING RADIOACTIVE ISOTOPES AND RADIOACTIVE MATERIALS FOR SEDIMENTATION AND HYDROLOGY RESEARCH.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
 - (c) Dr. J. Roger McHenry, Soil Scientist and Dr. L. L. McDowell, Soil Scientist, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
 - (d) Experimental basic research.
 - (e) To devise, develop, and utilize procedures for "tagging" sediment particles with radioisotopes and identifying same in the laboratory and in the field. Results are to be used in predicting sediment production, transport and deposition.
 - (g) A satisfactory method has been developed for "tagging" quartz sand particles with scandium-46, an energetic gamma emitter.
 - (h) "The Use of Radioactive Tracers in Sedimentation Research," by J. Roger McHenry and Leslie L. McDowell, Journal of Geophysical Research (in press).
- (4323) SEDIMENT PRODUCTION AND CONTROL PRACTICES ON HIGHWAY CUTS AND FILLS.
- (b) Laboratory project, in cooperation with the Georgia State Highway Department, and the University of Georgia College of Agriculture Experiment Stations.
 - (c) Mr. E. G. Diseker, Agricultural Engineer, P. O. Box 124, Cartersville, Georgia.
 - (d) Experimental, field; applied.
 - (e) Runoff and soil losses are measured from three pairs of bare, roadbank plots (approximately 1:1, 2:1, and 3:1) on Cecil Clay subsoil using six H-flumes and Coshockton vane samplers. Metal hub stakes are used as an adjunct in determining bank erosion, and for measuring deposition or scour from the flow channels. Over 30 different plants have been tested on 850 roadbank plots for erosion control. Studies for determining the best maintenance practices for adaptive plantings are in progress.
 - (g) Bare bank losses have varied from 25 to 360 tons per year per acre for the past 4 years depending on the rainfall, frost action, bank aspect and slope. Bank aspect and frost action have been major factors in the erosion process. Banks facing northwest have lost, on an average, 2.3 times as much soil as those facing southeast. Plants which have proved satisfactory for erosion control are fescue, common Bermudagrass, lovegrass, broomsedge, Pensacola and Wilmington Bahiagrasses, crownvetch, sericea lespedeza, honeysuckle and kudzu. For the establishment of satisfactory cover on slopes 2:1 and steeper, mulches were necessary particularly for the slowly developing plants such as crownvetch and Bahiagrasses. For maintenance of most plants, especially the grasses, a timely application of fertilizer is necessary.
- (h) "Roadside Sediment Production and Control," by E. G. Diseker and E. C. Richardson. Trans. ASAE, Vol. 4, No. 1, 62-64, 68, 1961.
 - "Control of Roadbank Erosion in the Southern Piedmont," by E. C. Richardson and E. G. Diseker. Agronomy Journal, Vol. 53:292-294, 1961.
- (4324) UTILIZATION OF TRITIUM IN WATERSHED RESEARCH STUDIES.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
 - (c) Dr. J. Roger McHenry, Soil Scientist, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
 - (d) Experimental basic research and development.
 - (e) To devise, develop, test and apply tracer techniques using tritium and other radioisotopes in support of studies of soil moisture and groundwater movement.
 - (g) Methods of high efficiency have been developed using a liquid scintillation counter. Preliminary laboratory studies have shown the precision and accuracy of the methods are adequate. Field testing will be initiated.
- (4325) RUNOFF FROM AGRICULTURAL WATERSHEDS.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
 - (c) Mr. W. R. Hamon, Research Agricultural Engineer, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
 - (d) Field investigations; basic and applied research.
 - (e) To develop procedures for predicting flood runoff, water yield and hydrograph characteristics for ungaged upstream watersheds. Runoff and precipitation are observed for the 117 square-mile Pigeon Roost Creek Watershed in Northern Mississippi including 11 sub-watersheds, and for four unit-source watersheds under 4 acres in size. These data, accumulated over the past four years, are being processed by computer and analyzed to develop synthetic unit hydrographs by incorporating antecedent soil moisture and watershed factors. The predicted hydrographs will be used to establish flow-duration curves.
 - (h) Hydrologic data releases are prepared yearly with summaries of monthly precipitation and runoff, tabulated annual maximum flows, and detailed data for selected runoff events.
- (4326) SUBSURFACE HYDROLOGY AND HYDROGEOLOGY.
- (b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
 - (c) Mr. F. E. Dendy, Agricultural Engineer, Sedimentation Laboratory, P. O. Box 158, University, Mississippi.
 - (d) Experimental and field investigations; basic and applied research.
 - (e) To study the hydraulic characteristics of geologic strata and develop methods of predicting ground water accretion and movement; subsurface and ground water contribution to streamflow from a knowledge of geology, soils, topography, climate, land use and treatment of agricultural watersheds; and to evaluate hydrogeologic factors governing transmission gains and losses in stream channels. A portable drilling rig is utilized to obtain geologic samples, establish ground water observation wells, and conduct permeability field tests.
 - (g) A map of the structural and stratigraphic

- characteristics of Pigeon Roost Creek Watershed is in preparation and seasonal ground water contours are being developed. Design and testing of a small well point for field observations of permeability has been completed.
- (h) "Utilization of Drilling and Resistivity Equipment in Ground Water Research," by Loris E. Asmussen, ARS Research Report No. 345, October 17, 1961.
"Permeability Measurements With Small Well Points," by Farris E. Dendy and Loris E. Asmussen, (in preparation).
- (4327) MOISTURE REGIMES OF AGRICULTURAL WATERSHEDS.
- (b) Laboratory project, cooperative with the Univ. of Miss. and Mississippi State Univ.
- (c) Mr. John Kozachyn, Soil Scientist, Sedimentation Lab., P.O. Box 158, University, Miss.
- (d) Field investigation; applied research.
- (e) To provide soil moisture data for the development of prediction techniques for runoff and sediment production and to relate the moisture regimes of agricultural watersheds to soil, climate and vegetative parameters. Field observations of soil moisture to depths of 10 and 20 feet are obtained by the neutron probe method for different cover, slope, and soil complexes.
- (g) The superiority of the neutron probe procedure over other available methods was established from laboratory and field tests. A method of installing access tubes has been perfected.
- (h) "A Method of Installing Access Tubes for Soil Moisture Measurement by the Neutron Probe Procedure," by John Kozachyn and J. Roger McHenry, ARS Research Report No. 326, March 14, 1960.
- (4328) RELATION OF CLIMATE AND SOIL MOISTURE LEVELS TO PLANT GROWTH AND WATER USE.
- (b) Laboratory project, cooperating with the Central and Southern Florida Flood Control District and the Florida Agricultural Experiment Station.
- (c) Mr. E. H. Stewart, Soil Scientist, P. O. Box 9087, Fort Lauderdale, Florida.
- (d) Laboratory and field investigations, both basic and applied for evaluating measured environmental conditions.
- (e) Laboratory and field procedures are employed to determine moisture intake, retention and transmission characteristics of mineral and organic soils. Controlled water table studies in non-weighing lysimeters are conducted to determine evapotranspiration, crop growth, and soil physical properties as influenced by various water table depths. Field and plot studies in organic soils are conducted to determine soil subsidence.
- (g) Moisture characteristics of some representative soils of Florida have been determined. Everglades peat has subsided about 1 foot every 10 years on the average. On controlled plots the subsidence rate was directly proportional to depth of water table. For organic soils, optimum depth to water table varies from 18 to 30 inches depending on crop type. For sandy soils, optimum depth to water table was 24 inches for most crops. St. Augustinegrass grown at water table depths from 12 to 36 inches consumed an average of about 46 inches of water a year. Neither ET nor yields were materially affected by water levels but protein content was better at water levels of 24 to 36 inches. The USWB pan, as an integrator of climate, was found to have a real value as an index of crop water requirements in the south Florida area where management does not permit soil moisture to become limiting.
- (h) "Applying Basic Soil Water Data to Water Control Programs in Everglades Peaty Muck," by H. A. Weaver and W. H. Speir, ARS 41-40, Nov. 1960.
"Some Drainage Characteristics of a Cultivated Organic Soil in the Everglades," by D. S. Harrison, H. A. Weaver, Proc. Soil and Crop Sci. Soc. Fla. Vol. 18, 1958.
"Some Considerations for Drainage of Flatwoods Soils Used in Vegetable Production," by D. S. Harrison, E. H. Stewart, and W. H. Speir, Proc. Fla. Hort. Soc. Vol. 73, Oct. 1960.
"Relation of Evaporation to Potential Evapotranspiration at Ft. Lauderdale, Fla." by J. C. Stephens and H. A. Weaver, Paper No. 60-204, Am. Soc. Agr. Eng. 1960.
"Subsidence of Organic Soils in the Florida Everglades," by J. C. Stephens, Proc. Soil Sci. Soc. America, Vol. 20, No. 1, 1956.
- (4329) HYDROLOGIC RESEARCH ON SMALL AGRICULTURAL WATERSHEDS IN CENTRAL AND SOUTHERN FLORIDA.
- (b) Laboratory project, cooperating with the Central and Southern Florida Flood Control Dist. and the Fla. Agric. Experiment Station.
- (c) Mr. John C. Stephens, Hydraulic Engineer, P. O. Box 9087, Fort Lauderdale, Fla.
- (d) Experimental, field investigations; basic and applied research.
- (e) To collect, analyze, and correlate basic hydrologic data on agricultural watersheds ranging in size from 4,000 to 63,000 acres in the Coastal Plain of Florida. To determine the influence of climate, topography, soils, geology, and land use on the rate and volume of runoff and to evaluate the water balance. To devise methods of interpreting watershed characteristics as similitudes related to physiography of other areas.
- (g) For an unimproved 98-sq. mile watershed the maximum daily discharge (Oct. 1956) was 2.28 inches-over-area with an instantaneous peak rate of 70 c.f.s./sq. mile; and for the 16-sq. mile upper sub-basin the respective rates were 3.14 inches and 158 c.f.s./sq. mile. The ratio of runoff to rainfall has averaged 0.35 for the larger and 0.28 for the smaller watershed over the past 5 years. Total water yield varied inversely with the size watershed. For the larger watershed base flow averaged 73, interflow 18, and overland flow 9 percent; and for the smaller watershed 34, 29, and 37 percent of total streamflow. Potential evapotranspiration losses for these basins were 78 percent of USWB pan rates, and annual ET losses were the most stable element in the hydrologic balance. Soil moisture conditions in the vadose zone seemed to influence base flow rates as much as ground water stages. Observations will continue to ascertain the effects of contemplated Watershed Protection and Flood Prevention Programs.
- (4330) RUNOFF AND EROSION CHARACTERIZATION OF BROWN LOAM SOILS.
- (b) Laboratory project.
- (c) Mr. Coy W. Doty, North Mississippi Branch Experiment Station, Holly Springs, Miss.
- (d) Experimental, field; basic and applied.
- (e) Rates and amounts of runoff and soil losses are measured on plots with land of five percent slope and degrees of ground cover ranging from continuous fallow to 2 years of sod and one year of corn, and with contour versus up- and down-hill tillage.
- (g) Both water and soil losses are excessive on bare land, and are reduced as the degree of ground cover is increased.
- (4331) HYDRAULICS OF FARM WATER CONTROL IN THE SOUTHERN PIEDMONT.
- (b) Soil and Water Conservation Research Div., Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Univ. of Georgia, College of Agriculture Experiment Stations.

- (c) Mr. W. Campbell Little, Agricultural Engineer, Southern Piedmont Soil Conservation Field Station, Box 33, Watkinsville, Georgia.
- (d) Experimental laboratory; basic and applied.
- (e) Basic research on the mechanics of erosion and hydraulics of flow in individual crop rows and in terraced channels will be constructed using a 60-foot tilting laboratory flume. Design criteria will be developed for both terrace systems and individual row systems for the different soils of the Piedmont. It is anticipated that this work will be underway by July 1962.
- (g) Under construction.
- (4332) SURFACE DRAINAGE -- ROW LENGTHS AND GRADES FOR REMOVAL AND APPLICATION OF SURFACE WATER ON FORMED AGRICULTURAL LAND OF THE MISSISSIPPI DELTA.
- (b) Soil and Water Conservation Research Div., Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Louisiana Agricultural Experiment Station.
- (c) Mr. Irwin L. Saveson, Project Administrator, Agricultural Engineering Building, LSU, Baton Rouge, Louisiana, P. O. Box 8817, University Station.
- (d) Experimental; basic and applied research.
- (e) Approximately 80 acres of land have been formed with four different slopes, in two replications, of 0.1', 1.15', 0.2', and 0.25'. For each slope class, row lengths of 500', 700', 900', and 1,100' will be used to determine the maximum row length for formed land as related to slope. Runoff, time-of-concentration, infiltration, soil temperature, and soil moisture data will be gathered and correlated with rainfall, wind humidity, and sunshine radiation. Future studies are contemplated to evaluate flow characteristics of surface water in furrows on agricultural land. This information will be used to develop a furrow cross-section with the best hydraulic characteristics.
- (g) Being established and expected to be in full operation in 1962.
- (h) Annual Station progress reports.
- (4333) RUNOFF AND EROSION STUDIES FOR THE SOUTHERN PIEDMONT.
- (b) Soil and Water Conservation Research Div., Agricultural Research Service, Watkinsville, Georgia, in cooperation with the University of Georgia, College of Agriculture Experiment Stations.
- (c) Mr. A. P. Barnett of Mr. J. S. Rogers, Agricultural Engineers, Southern Piedmont Soil Conservation Field Station, Box 33, Watkinsville, Georgia.
- (d) Experimental field investigations, development and applied; some parts to be used for Masters Thesis.
- (e) The purpose of these studies is to determine the interrelations of climate, soil, topography, cover, management, row direction, runoff, soil movement and loss from Southern Piedmont soils. The work is conducted on fractional acre field plots under both natural and simulated rainfall. The natural rainfall plot study includes six cover, two row direction and three slope steepness treatments on a total of 42 plots. Total amounts of runoff and soil loss are measured for individual rainstorms. Meteorological data are also secured. The rainfall simulator designed to apply rain at 5, 2-1/2 and 1-1/4 inches per hour simultaneously to three adjacent plots is used to secure runoff and soil loss data from specific soil, slope, crop, and management complexes through the application of designed storms. These data will be used to evaluate their runoff and erosion control effectiveness.
- (g) Progress is reported each year in Station annual reports.
- (4334) RUNOFF AND EROSION STUDIES FOR SOUTHERN COASTAL PLAINS SOILS.
- (b) Soil and Water Conservation Research Div., Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with Georgia Agricultural Experiment Stations.
- (c) Mr. G. N. Sparrow, Agricultural Engineer, Georgia Coastal Plain Experiment Station, Tifton, Georgia.
- (d) Field investigations; applied, for design.
- (e) The purpose of these studies is to determine interrelations of climate, soil, cover, runoff and soil loss for Southern Coastal Plain soils. The work is conducted on 18 field plots, 1/20 acre in size, under natural rainfall. There are four cover treatments. Total amount of runoff and soil loss are measured for individual storms. Meteorological data are also secured.
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- U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.
- SOUTHERN PLAINS BRANCH, 804 Bryan Street, Amarillo, Texas, Dr. J. R. Johnston, Branch Chief.
- (3876) SOIL-WATER-PLANT RELATIONSHIPS OF COTTON AS AFFECTED BY SOIL MOISTURE REGIME.
- (b) Laboratory project.
- (c) Mr. L. N. Namken, Soil Scientist, P. O. Box 267, Weslaco, Texas.
- (d) Field investigation - applied research.
- (e) The project is statistically designed as a 4 x 4 latin square including 4 moisture level treatments, replicated 4 times. The project is designed to provide information concerning changes in the moisture extraction pattern associated with the stage of growth and development of the cotton plant. In areas where the probability of a short supply of water is great, it is particularly desirable to know not only how much moisture is being extracted from the profile, but also from where in the profile the extraction is concentrated.
- (h) "An Economical "Go-cart" for a Neutron Probe and Scanner," by M. Amemiya and L. N. Namken, Soil Science Society of America, Proceedings, Vol. 24, No. 6, p. 528, 1960.
- (3879) CHARACTERIZATION OF THE "HOT SPOT" PROBLEM IN THE LOWER RIO GRANDE VALLEY OF TEXAS.
- (b) Laboratory project.
- (c) Mr. L. Roy Ussery, Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
- (d) Experimental and field investigation - applied research.
- (e) Purpose of this study is to define the causes of salt accumulation in soil profiles in the nonirrigated area of the Lower Rio Grande Valley of Texas. Investigations include studies of ground surface and water-table topography, physical and chemical characteristics of soil profiles, soil management practices and climatic conditions, as related to occurrence of soil salinity.
- (3880) THE MICRODYNAMICS OF UNSATURATED MOISTURE FLOW.
- (b) Laboratory project.
- (c) Dr. Craig L. Wiegand, Soil Scientist, P. O. Box 267, Weslaco, Texas.
- (d) Experimental, basic research.
- (e) The objectives are to obtain evidence on the generality of the parabolic moisture distribution with respect to the interface of extraction and to interpret unsaturated moisture flow in terms of molecular level

- mechanisms of flow. The experimental technique is that of inducing moisture flow by various techniques at a series of temperatures and measuring the flow rate. The Arrhenius equation is applied to the data and an activation energy calculated. The activation energy is then interpreted in terms of energy barriers to molecular level flow mechanisms. The soil columns are sampled at the end of the runs to determine the moisture distribution with respect to the interface of extraction.
- (g) The results to date indicate that the resulting moisture distribution is a function of peculiarities of the microdynamic flow processes involved and independent of the method of extraction.
- (3381) FACTORS AFFECTING THE EVAPORATION OF FREE WATER.
- (b) Laboratory project.
- (c) Dr. Craig L. Wiegand, Soil Scientist, P. O. Box 267, Weslaco, Texas.
- (d) Experimental, basic research.
- (e) The evaporation of free water is being studied under controlled conditions to:
- (1) Obtain quantitative information on the rate of evaporation of free water under controlled atmospheric conditions; (2) measure the rate of evaporation of water as a function of water temperature; and (3) correlate the rate of evaporation with (a) the saturation deficit of the atmosphere, and (b) the fugacity of the water molecules. Evaporation is being measured under all combinations of 10, 20, 30, and 40 degrees C water temperature; 10, 20, 30, and 40 degrees C air temperature; and 30, 50, 70, and 90% relative humidity. Water temperature is controlled to plus or minus 1.0 degrees C, and relative humidity to plus or minus 3%.
- (g) One-fourth of the possible "treatment" combinations has been studied - all ambient and water temperatures at 30% relative humidity. The results indicate that the evaporation rate is more a function of the capacity of air to take on moisture than of the escaping tendency of the water molecules. In agreement with psychrometric principles water condenses into the water reservoir when the temperature of the water is below the dew point temperature for the ambient temperature and humidity conditions prevailing.
- (4335) THE HYDRAULICS OF STRUCTURES USED IN SOIL AND WATER CONSERVATION WORKS.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
- (d) Experimental and field investigation, applied research for design.
- (e) Experiments employ small scale models as well as full size structures tested under simulated natural conditions to develop designs for structures needed for soil and water conservation. Closed conduit spillway entrances including drop inlets, hood inlets, and orifice plates are tested. Debris guards are tested using full size structures to provide verification of the small models.
- (g) A technique for testing models of debris guards has been developed which satisfactorily simulates full size structure performance.
- (4336) DESIGN AND CALIBRATION OF DEVICES FOR THE MEASUREMENT OF RUNOFF.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
- (d) Experimental, applied research.
- (e) The measuring devices tested are used in the hydrology research program of the Agricultural Research Service. Sites for runoff measuring stations are surveyed and then modeled in the laboratory. Proposed structures are placed in the model and tested to develop a satisfactory design. The final design is calibrated by model tests. All current work is on specific sites and no general experiments are done. During the past year a number of variations on a V-notch weir for Switzer Creek, Cohocton, New York, have been rated. Some of the field conditions indicated channel control, so considerable attention was given to the friction characteristics of the model.
- (g) During the past year a number of variations on a V-notch weir for Switzer Creek, Cohocton, New York, have been rated. Some of the field conditions indicated channel control, so considerable attention was given to the friction characteristics of the model.
- (4337) HYDRAULICS OF FLOW IN VEGETATION LINED CHANNELS.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
- (d) Experimental, applied research.
- (e) Channels or portions of channels are built full size on the outdoor hydraulic laboratory grounds. These are planted to the vegetation being investigated and then tested by flowing water at selected times. Friction factors and permissible velocities (or tractive force values) are determined. In recent years the establishment phase of vegetal channels has received the greater emphasis. This has included the evaluation of temporary, fabricated liners of jute, glass fiber, and asphalt.
- (g) Friction factor values and permissible velocities for vegetation lined waterways which were found by this station now appear in many publications, including the "Handbook of Channel Design for Soil and Water Conservation," SCS-TF-61.
- (4338) HYDRAULICS OF UNSTEADY FLOW IN OPEN CHANNELS.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
- (d) Experimental, applied research.
- (e) Studies are made of unsteady flow phenomena occurring in the runoff process. The initial phase of the study is an analytical one utilizing existing knowledge and theory. This phase will be followed by a large scale outdoor laboratory study to test hypotheses and evaluate coefficients.
- (f) Now being initiated.
- (4339) RUNOFF CHARACTERISTICS OF AGRICULTURAL AREAS IN THE RED PRAIRIE OF OKLAHOMA.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
- (d) Field investigation, applied research for design.
- (e) Three watersheds, 17 acres, 92 acres, and 206 acres in size and covered with native grass, are instrumented to measure rainfall and runoff. Annual water yield as well as peak flood flows are determined. Selected runoff events provide data for distribution graphs or unit hydrograph development.
- (g) Data from 10 years of measurement are available.
- (4340) SEDIMENT PRODUCTION, MOVEMENT AND DEPOSITION IN THE WASHITA RIVER BASIN, OKLAHOMA.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Field investigation, applied research.
- (e) Suspended sediment sampling and total

- sediment transport determinations are made at selected tributary and main stream locations in the Washita River Basin. These samples are analyzed for size distribution.
- (f) Project initiated in 1961.
- (4341) STREAM CHANNEL STABILIZATION AND SEDIMENT CONTROL WORKS IN CHANNELS OF THE WASHITA RIVER BASIN.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Field investigation, applied research.
- (e) Selected reaches of channels representing different geologies, soils, and flow regimes are being established for detailed studies of stream channel morphology. Information is obtained on cross-sections, slopes, thalweg lengths, alignments, vegetation, and bed and bank materials. Any control works are completely identified as to location, orientation, shape, size, and materials. Flow history will be recorded, including both water and sediment. Changes in channel conditions, or lack of change, will be related to flow history and other controlling factors for the development of criteria for stable channel design.
- (f) Project initiated in 1961.
- (4342) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE WASHITA RIVER BASIN, OKLAHOMA.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Field investigation, applied research.
- (e) A network of 170 recording precipitation gages has been established on a 3-mile grid in an 1100-square mile area in the central portion of the Washita River Basin. The precipitation characteristics will be analyzed to determine and evaluate precipitation parameters useful in estimating runoff.
- (f) Project initiated in 1961.
- (4343) RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE WASHITA RIVER BASIN, OKLAHOMA.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Field investigation, applied research.
- (e) Small watersheds generally not exceeding 10 acres in size, each representing a single soil-cover combination are being instrumented to measure rainfall, runoff, and soil moisture. Information on the runoff producing characteristics of the unit source areas will be useful in the development of equations for predicting runoff from ungauged complex watersheds.
- (f) Project initiated in 1961.
- (4344) RELATION OF CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF AND WATER YIELD OF THE WASHITA RIVER AND TRIBUTARIES, OKLAHOMA.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Field investigation, applied research.
- (e) A reach of the Washita River extending from Anadarko, Oklahoma, to Alex, Oklahoma, has been selected for study. This reach has a length of 80 river miles and a drainage area along this length of 1120 square miles. Gaging stations are being established near the mouth of 20 tributaries and at 6 sites along the main stem of the Washita River in this reach. Watershed characteristics are being measured and defined. The watershed land use and structures development will be inventoried periodically. Flood peaks, total flow and its rate-time distribution will be determined and related to climatic and land factors.
- (f) Project initiated in 1961.
- (4345) EXPLORATORY STUDY OF THE REGIMES OF WASHITA RIVER MAIN STEM FLOWS.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Analysis of record, applied research.
- (e) The flow history of the Washita River, Oklahoma, for the 10-year period 1941 to 1950 is being analyzed to: (1) Determine parameters characterizing the regime flows prior to development of upstream flood abatement measures; and (2) establish a base for reference in defining any future changes in flow regimes associated with conservation and treatment programs in tributary watersheds.
- (f) Project initiated in 1961.
- (4346) AQUIFER-STREAMFLOW RELATIONS, GROUND WATER BUDGET, WASHITA RIVER BASIN, OKLAHOMA.
- (b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
- (c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
- (d) Field investigation, applied research.
- (e) The alluvia and underground flow system of the Washita River Basin are being defined by use of drilling equipment and existing well logs. Permeability coefficients will be determined and ground water observation wells established. This is one part of a comprehensive research study of the total water budget in a portion of the Washita River Basin.
- (f) Project initiated in 1961.
- (4347) AN INVESTIGATION OF RAINFALL-RUNOFF RELATIONSHIPS IN TEN COASTAL AREAS OF THE LOWER RIO GRANDE VALLEY.
- (b) Laboratory project, cooperative with the Texas Agricultural Experiment Station.
- (c) Mr. R. R. Allen, Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
- (d) Field investigation, applied research for design.
- (e) The project will provide data on runoff volumes needed for the design of drainage systems for the flat, coastal areas. A 3250-acre, non-leveled, dry land tract is instrumented to measure rainfall and runoff. Data are also obtained on land and soil characteristics as well as the climatic variables.
- (f) The project was started in December 1961.
- (4348) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM SELECTED AREAS IN TEXAS.
- (b) Laboratory project.
- (c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
- (d) Field investigation, applied research.
- (e) Rain gage networks are established on the Blacklands Experimental Watershed near Riesel, Texas, and on the Edwards Plateau near Sonora, Texas. Information is being obtained on amounts, duration, seasonal distribution, and other characteristics of rainfall to the extent that the characteristics influence runoff from agricultural watersheds. The work at Sonora, Texas, was initiated in 1961.
- (4349) RELATION OF CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF AND TO WATER YIELD FROM AGRICULTURAL WATERSHEDS IN THE BLACKLANDS OF TEXAS.

- (b) Laboratory project.
 - (c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
 - (d) Field investigation, applied research.
 - (e) Thirty watersheds, varying in size from approximately 3 acres to 5860 acres, have been equipped with precalibrated flumes or with current meter rated weirs to measure runoff rates. Precipitation is measured by recording rain gages. The land factors are determined by periodic inventory of crops, covers, and crop systems on the land. Relationships between climatic and land factors and the runoff produced are analyzed to develop prediction methods for estimating storm peaks and water yields.
 - (h) Monthly summaries of rainfall and runoff, maximum volumes of flow for selected periods of time, and detailed data for selected runoff events are reported annually. Several analytical and interpretive reports have been published.
- (4350) RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE BLACKLANDS OF TEXAS.
- (b) Laboratory project.
 - (c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
 - (d) Field investigation, applied research.
 - (e) Twelve watersheds, approximately 3 acres in size each, of single land use, crop or grass, are instrumented with H-type flumes to measure the runoff. The relationships between the runoff and the associated precipitation as influenced by the land characteristics are investigated. These relationships will facilitate the prediction of runoff from ungaged watersheds composed of combination of these single soil-cover, sub-watersheds or unit source areas.
 - (h) Monthly summaries of rainfall and runoff, maximum volumes of flow for selected periods of time, and detailed data for selected runoff events are reported annually.
- (4351) SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS OF AGRICULTURAL AREAS IN THE TEXAS BLACKLANDS.
- (b) Laboratory project.
 - (c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
 - (d) Field investigation, applied research.
 - (e) Sediment yield measurements have been or are being made on twenty-four plots or watersheds varying in size from one-quarter to 5860 acres. These sediment yields are correlated with precipitation, runoff, topography, soils, land use, and conservation practices. The data are analyzed to develop techniques and procedures for estimating sediment yield and sources from ungaged watersheds.
- (4352) RELATION OF CLIMATIC AND WATERSHED CHARACTERISTICS TO STORM RUNOFF AND WATER YIELD IN THE EDWARDS PLATEAU AREA OF WEST CENTRAL TEXAS.
- (b) Laboratory project.
 - (c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
 - (d) Field investigation, applied research.
 - (e) Five detention reservoirs in Lowrey Draw are equipped with water level recorders. Runoff volumes are measured by volume change in the reservoir. Rates of inflow can also be determined. The watersheds above the reservoirs range in size from 686 to 10787 acres. A current meter rated gaging station will be placed at the outlet of the Lowrey Draw watershed which has a drainage area of 48 square miles. A rain gage network will determine the precipitation over the area. In addition to the development of the rainfall-runoff relationship for this area, a study will be made of the disposition of the water temporarily stored in the reservoirs.
- (f) Project initiated in 1961.
- (4353) EVALUATION OF OPERATION AND DESIGN CRITERIA OF OLD TILE DRAIN SYSTEMS.
- (b) Laboratory project.
 - (c) Mr. Victor I. Myers, Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
 - (d) Field investigation - applied research.
 - (e) A study to evaluate the effectiveness of some old existing tile systems in draining and leaching soils; to evaluate the functioning of tile drains with and without filter materials; and, to evaluate the adequacy of tile drain design criteria.
 - (g) Investigations show that many tile systems, up to 20 years old, are only partially effective because of inadequate design or for lack of filters. Poor maintenance of drainage outlets and tile systems is also a major cause contributing to failure of buried drains. Data being collected as sections of old tile lines are dug out and examined will contribute to a drainage guide for the design and installation of drain tile in the Lower Rio Grande Valley.
- (4354) INFILTRATION RATES AND PROFILE CHARACTERISTICS IN RELATION TO THE OCCURRENCE OF SALINITY.
- (b) Laboratory project.
 - (c) Mr. Leon Lyles, Agricultural Engineer, or Dr. Craig Wiegand, Soil Scientist, P. O. Box 267 Weslaco, Texas.
 - (d) Field investigation; applied research.
 - (e) The purpose of the work is to relate infiltration rates to the occurrence of salt-affected soil profiles. Infiltration rates are to be determined on about a dozen salt affected and adjacent non-affected profile pairs which have been chemically and physically characterized. The infiltration rates will be related statistically to the severity of salinization and to the chemical and physical properties of the profiles.
 - (f) Pending final approval.
- (4355) CONCENTRATIONS OF SALTS IN RAINFALL IN THE LOWER RIO GRANDE VALLEY.
- (b) Laboratory project.
 - (c) Mr. Carl D. Fanning, Soil Scientist, P. O. Box 267, Weslaco, Texas.
 - (d) Field investigation - basic research.
 - (e) The project is a rainwater sampling study to determine the quantity of salts present in rainwater of varying storm types at the coast line and extending inland approximately 90 miles.
- (4356) EFFECTS OF BENCHING AND TERRACING ON MOISTURE CONSERVATION ON SLOPING HARDLANDS OF THE SOUTHERN GREAT PLAINS.
- (b) Laboratory project.
 - (c) Mr. Victor L. Hauser, Agricultural Engineer, Southwestern Great Plains Field Station, Bushland, Texas.
 - (d) Field investigation, applied and design research.
 - (e) 1. To test the feasibility of altering the configuration of the land to intercept, spread, and infiltrate surface runoff in contour basins. 2. To determine the extent to which such intercepted runoff will add to available soil moisture supplies and how such additional soil moisture may best be utilized for crop production. 3. To determine the relative value of the three types of terrace systems, conservation benching, graded, and level closed end for moisture conservation and crop production.
- (4357) EFFECT OF CROPPING SYSTEMS AND CLIMATE ON RUNOFF AND EROSION UNDER BLACKLANDS CONDITIONS.

- (b) Laboratory project.
- (c) Dr. R. M. Smith, Soil Scientist, P. O. Box 414, Temple, Texas.
- (d) Experimental - applied research.
- (e) Runoff and soil loss are measured from 12 field-scale (1-1/2 acre) plots representing typical cultivated slopes of Blackland Prairie soils in three systems with row cropping every year, in alternate years, and every third year. Interactions of varying climatic influences with crops and management are determined as a basis for runoff, erosion and crop yield calculations on farms and watersheds.
- (g) Soil moisture is the dominant factor influencing runoff in this high-shrinking soil. Erosion per unit of runoff is strongly influenced by surface residues as well as live crop growth. During three years grain sorghum has resulted in about one-half as much erosion as corn or cotton and only slightly more than oats. Effectiveness of grain sorghum is increased especially by thick early stands and managing residues on the surface.
- (h) "Interpretations of Runoff and Erosion from Field Scale Plots on Texas Blackland Soil," by J. E. Adams, R. C. Henderson, and R. M. Smith, Soil Science, Vol. 87, No. 4, pp. 232-238, 1959.
"Surface Residues Reduce Erosion in the Blacklands," by R. M. Smith and R. C. Henderson, Soil and Water Mag. (Assoc. Tex. Soil Conserv. Dist.), Vol. 10, No. 9, p. 8, September 1960.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

SOUTHWEST BRANCH, P. O. Box 2326, Riverside, Calif.,
Mr. W. W. Donnan, Branch Chief.

(151) LINING OF IRRIGATION CANALS AND RESERVOIRS.

- (b) Laboratory project, Agricultural Research Service, Utah State University, and Bureau of Reclamation cooperating.
- (c) Dr. C. W. Lauritzen, Soil Scientist, Utah State University, 101 Engineering Building, Logan, Utah.
- (d) Experimental; basic and applied research.
- (e) Linings for irrigation canals and reservoirs are being tested to develop more effective and lower cost methods of reducing seepage losses in irrigation systems. The investigation included: (1) Evaluation of physical properties of lining materials; (2) model testing of linings in an outdoor laboratory; and (3) field testing at selected sites to determine relative durability under varying subgrade and climatic conditions.
- (g) The target date indicated in last year's report for having an asphalt-coated jute liner on the market was not met. Some technical problems still persist, but the chief difficulty has been plant and material problems. Membrane linings consisting of a 15 gage butyl sheeting look promising as buried liners for canals and reservoirs. Butyl, even in the thinner gages, because of its excellent aging characteristics may also be used as an exposed lining in reservoirs if precautions are taken to protect it from mechanical damage. Some work was done on the use of latex additives to portland cement concrete mixes with the idea of developing a material adapted to use in water conveyance structures. Lattices, such as butyl and butadiene-styrene, when added to portland cement concrete mixes will reduce the shrinkage which accompanies curing and, depending upon the aggregate and lattice, modify other properties such as tensile and compressive strength and water absorption.
- (i) "Elastic Films for Water Storage," by C. W.

Lauritzen, Journal American Water Works Association, Vol. 53, No. 2, pp. 135-140, Feb. 1961.

(2117) WATER REQUIREMENTS IN IRRIGATED AREAS OF SOUTHWEST.

- (b) Laboratory project in cooperation with State and Federal agencies.
- (c) Mr. Dean C. Muckel, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.
- (d) Field experiments and office analysis. Applied research.
- (e) To determine the consumptive use of water by irrigated crops, phreatophytes, and other vegetation, and irrigation requirements. To develop empirical formula from climatological and other data for determining rates of consumptive use.
- (f) Study has been underway for several years and is still active.
- (g) Monthly coefficients (k) have been revised for irrigated crops and phreatophytes in the Blaney-Criddle formula, $u = kf =$ consumptive use, where "k" is a monthly coefficient based on experimental measurements, and "f" is a factor determined from mean monthly temperatures and percent of daytime hours. A report is in preparation which includes results of studies in United States and foreign countries. Monthly (k) and seasonal (k) coefficients are given for alfalfa, cotton, citrus, small grain, and other irrigated crops.
- (h) "Consumptive Use and Water Waste by Phreatophytes," by Harry F. Blaney, Paper No. 2929, Jour. of Irrigation and Drainage Division Proceedings, American Society of Civil Engineers, September 1961.
"Determining Consumptive Use and Irrigation Water Requirements," by Harry F. Blaney and Wayne D. Criddle, Agricultural Research Service, United States Department of Agriculture, 1962 (In press).
"Monthly Consumptive Use Requirements for Irrigated Crops," (closure), by Harry F. Blaney, Journ. of Irrigation and Drainage Div. Proceedings, ASCE, Paper No. 2536, June 1961.
"Los Angeles Water Supply and Irrigation," by Samuel Morris and "Method for Estimating Consumptive Use of Water for Agriculture," by Wendell Muson, Discussions by Harry F. Blaney, Vol. 97, IR3, Journal of Irrigation and Drainage Division Proceedings, ASCE, September 1961.

(2180) EVAPORATION LOSSES FROM RESERVOIRS AND LAKES.

- (b) Laboratory project in cooperation with State of California, counties and other agencies.
- (c) Mr. Dean C. Muckel, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.
- (d) Experimental; compilation and analysis of data. Applied research.
- (e) To determine evaporation losses from reservoirs and lakes and develop empirical formulas from climatological data for computing monthly evaporation. Cooperative field measurements are being made of pan evaporation at stations in California ranging from near sea level in Santa Barbara County to 9,194 feet elevation at Kaiser Pass in the Sierra-Nevada Mountains.
- (g) Results of monthly pan evaporation, temperature, humidity and wind movement and precipitation measurements have been published in California State Department of Water Resources Bulletins Nos. 54-B and 73, "Evaporation from Water Surfaces in Calif.," by Harry F. Blaney and Dean C. Muckel. Due to the severe winter conditions at high elevations in the Sierra-Nevada Mountains, observations can only be made during a five to seven month period. In the 1961 Progress Report on "Evaporation Studies at High

- Elevations in San Joaquin River Basin Calif.," by Harry F. Blaney and Leonard L. Longacre, regression equations based on monthly evaporation and other data were developed from which evaporation for missing winter months may be computed. These equations are based on the average of 13-year records at each station.
- (h) "Evaporation at High Elevations - San Joaquin River Basin California," by Leonard L. Longacre, Southern California Edison Co., and Harry F. Blaney, U. S. Dept. of Agric. Approved for publication in the Jour. of Irrigation and Drainage Division Proceedings, ASCE, 1962.
- (2181) STORAGE OF WATER UNDER GROUND FOR IRRIGATION IN CALIFORNIA.
- (b) Laboratory and field project.
- (c) Mr. Leonard Schiff, Hydraulic Engineer, 4816 East Shields Avenue, Fresno 3, Calif.
- (d) Experimental; laboratory and field investigations, applied research.
- (e) To efficiently store and use underground water in quantity and of a quality needed in various locations. The objectives are: (1) To determine the physical and chemical characteristics of surface soil and sub-strata on selected sites and to relate these characteristics to infiltration and percolation rates and to lateral flow; (2) to determine the feasibility of recharge irrigation (deep percolation by sufficient irrigation of crops) as a means of storing water underground; (3) to determine the effect of recharge on the quality of water reaching the groundwater table under selected site conditions and on the quality of the groundwater; and, (4) to prepare a recharge guide which permits the evaluation of a site for recharge, suggests methods and systems of recharge to be used and indicates the quality of groundwater that may be expected as a result of recharge.
- (2550) EFFECT OF WATER TABLE DEPTH ON IRRIGATION REQUIREMENTS AND YIELD OF LAHONTAN ALFALFA.
- (b) Laboratory project.
- (c) Mr. Rhys Tovey, Agricultural Engineer, Box 8014, University Station, Reno, Nevada.
- (d) Experimental; applied research.
- (e) To determine surface-irrigation requirements of Lahontan alfalfa grown on three soil textures with constant water tables at various depths, and on well-drained soil in the absence of a water table; to determine the effect of plant growth stage on the rate of water use by Lahontan alfalfa; to determine the relation between the use of water by alfalfa under various water table conditions, evaporation from porous atmometer bulbs, and evaporation from a Weather Bureau evaporation pan; and to evaluate the effects of a fluctuating water table on the yield and growth rate of alfalfa.
- (g) The seasonal values indicate that: (1) The consumptive use and yield of alfalfa for the non-irrigated treatments decreased as the depth to water table increased; (2) the non-irrigated lysimeter show a lower consumptive use and yield than the irrigated lysimeters in most instances; (3) the consumptive use and yield of the drained irrigated treatments are comparable to the values measured for the eight-foot water table, non-irrigated treatment; and (4) the differences due to water table depth are less for the non-irrigated treatments.
- (2551) DRAINAGE INVESTIGATIONS IN THE NORTH SHORE AREA OF CARSON LAKE, NEVADA.
- (b) U. S. Department of Agriculture, ARS, Soil and Water Conservation Research Division.
- (c) Mr. Anthony S. Dylla, Agricultural Engineer, Box 8014, University Station, Reno, Nevada.
- (d) Field and applied research.
- (e) To determine the causes for drainage problems in the study area, to develop equipment and techniques suited to conditions in the study area which will permit determining qualitative and, if possible, quantitative relationships between causes for drainage problems in the study area and in other similar areas; to develop physically and economically feasible methods of correcting or alleviating problems in the study area and in other similar areas.
- (g) Canal seepage measurements are being analyzed for relationship high water table build-up. Investigative borings are being compiled for determination of corrective drainage measures. Hydraulic conductivity and specific yield determinations are being compiled for design of corrective drainage measures. Plastic lined mole drains are being studied as a possible economical drainage problem. Well, piezometer, and irrigation efficiency data are being compiled for analyzing the cause for drainage problems.
- (h) "Procedures for Evaluating Drainage Project Feasibility," by Victor I. Myers, Trans. of Fourth Congress, International Commission on Irrigation and Drainage, Madrid, Spain, June, 1960.
- (3212) THE HYDRAULICS OF CYLINDER INFILTRMETERS.
- (b) Laboratory project. Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Dept. of Agriculture in cooperation with the California Agricultural Experiment Station, Davis, California.
- (c) Mr. Charles T. Bourns, Agricultural Engineer, Room 215, Irrigation Building, University of California, Davis, California.
- (d) Experimental and basic research and developmental.
- (e) This is a three dimension model study of the hydraulics of cylinder-type infiltrometer to determine the flow regime of this device, the necessity for buffer cylinders, the effect of diameter on its function, the effect of methods and depths of placement on results, the effect of location of less permeable soil strata in relation to depth of placement of infiltrometer, and the effect of various operational techniques on reliability of results.
- (3556) FARM CONVEYANCE AND WATER APPLICATIONS.
- (b) Laboratory project, Agricultural Research Service and Utah State University cooperating.
- (c) Dr. C. W. Lauritzen, Soil Scientist, Utah State University, 101 Engineering Bldg., Logan, Utah.
- (d) Experimental; basic and applied research.
- (e) New methods and equipment for conveying and applying irrigation water are being developed. The hydraulic properties of lay-flat tubing are being studied and new materials are being evaluated to determine their use in conveyance structures.
- (g) With improved design lay-flat tubing as a replacement for head ditches is increasingly promising. There is an indication also that the tubing can be adapted to use as sprinkler laterals. An improved hopper has been developed for the subgrade-guided slipforms used in placing concrete linings in irrigation ditches. The problem of distributing the mix in the hopper has been solved by the use of a cone section.
- (3558) LABORATORY MODEL STUDIES OF THE SEDIMENT SEALING PROCESS.
- (b) Laboratory project.
- (c) Mr. Myron B. Rollins, Soil Scientist, P. O. Box 8014, University Station, Reno, Nevada.
- (d) Experimental; applied research.
- (e) To determine factors influencing sediment penetration and retention involved with

sealing irrigation canals or reservoirs with seepage transported bentonite, and to develop procedures to obtain effective seals. Experimentation is being done with sands placed in lucite cylinders 3 inches in diameter and 2 feet long. Bentonite is applied by dispersing it in the water, percolation carries the bentonite down into the sand profile. Numerous aspects concerning the chemical, physical and mineralogical properties of the bentonites, waters, and sands will be evaluated.

- (f) Active.
- (g) Preliminary investigations suggest that effective seals can be obtained within certain unknown limitations.

(3560) EVAPOTRANSPIRATION OF HUMBOLDT MEADOW VEGETATION AS MEASURED WITH LYSIMETERS.

- (b) Laboratory project.
- (c) Mr. Anthony S. Dylla, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.
- (d) Experimental; applied research.
- (e) To measure the evapo-transpiration of meadow vegetation in the Humboldt Basin area which subsists primarily under shallow water table conditions. The data will be used to determine areal use of ground waters by vegetation and to develop methods of more efficient utilization of those water supplies.
- (g) Evapo-transpirational rates are being obtained by water use measurements of meadow grasses growing in plastic lysimeters. Vegetative growth, soil moisture, water table, and weather data are being collected to which evapo-transpiration rates from tanks can be related.

(3868) A STUDY OF THE MECHANISMS AND MATHEMATICS OF WATER MOVEMENT IN UNSATURATED SOIL.

- (b) Laboratory project.
- (c) Dr. W. R. Gardner, Salinity Laboratory, P. O. Box 672, Riverside, Calif.
- (d) Experimental and theoretical; basic research.
- (e) Experimental techniques are being devised to measure the water-transmitting properties of unsaturated soils as a function of other soil properties. Methods are being devised to obtain solutions of various unsaturated-flow problems.
- (g) Several methods have been devised for measuring the capillary conductivity of soils, including a method for in situ measurements in the field in the tensiometer range. Solutions have been obtained for the movement of water to a plant root and for the drainage of a vertical soil column.
- (h) "Approximate Solution of a Non-steady State Drainage Problem," by W. R. Gardner, Soil Sci. Soc. Am. Proc. (in press).
"Unsaturated Conductivity and Diffusivity Measurements by a Constant Flux Method," by W. R. Gardner, and F. J. Miklich. Soil Sci. (in press).
"Measurement of Capillary Conductivity and Diffusivity with a Tensiometer," by W. R. Gardner, Trans. VII Cong. Internatl. Soil Sci. Soc. (in press).

(3872) DYNAMIC SIMILARITY IN PIPE ELBOW FLOW METERS.

- (b) Laboratory project.
- (c) Mr. Lloyd E. Myers, Director, Water Conservation Laboratory, Route 2, Box 816-A, Tempe, Arizona.
- (d) Experimental; applied research.
- (e) The objective of the study is the development of means for obtaining dynamic similarity in pipe elbow flow meters to permit the use of standard rating curves. ASA, class 125 cast iron 90 degrees flanged, 3" long and short radius elbows made by five different manufacturers were calibrated. Magnitudes of errors caused by flow disturbances from gate valves, bends, misalignment, centrifugal pump,

and straightening vanes were determined. Also errors caused by variation in tap location were evaluated. Lengths of straight pipe required to dampen flow disturbances were determined. Two types of straightening vanes were tested to reduce flow disturbance caused from a bend. Effect of larger diameter taps will be evaluated and rating curves for larger size elbows will be obtained.

- (g) Comparison of rating curves by a percent variation in discharge from an average rating curve gave results within plus or minus 3 percent. A gate valve caused the maximum error of the flow disturbances tested. Reasonable care in locating taps will not effect rating curve. Twenty diameters of straight pipe was sufficient to dampen flow disturbances, however, upstream and downstream pipe should be carefully aligned with elbow flow meter. The straightening vanes were not satisfactory for dampening flow disturbance from a bend since they induce a flow disturbance themselves.

(3873) GROUND COVERS AND OTHER STRUCTURES FOR COLLECTING AND STORING PRECIPITATION.

- (b) Field and laboratory project, Agricultural Research Service and Utah State University cooperating.
- (c) Dr. C. W. Lauritzen, Soil Scientist, Utah State University, 101 Engineering Building, Logan, Utah.
- (d) Experimental and applied research.
- (e) There are areas in many regions where water for livestock and even culinary uses is scarce or nonexistent, yet considerable water in the form of precipitation falls each year. As an example, the precipitation on one acre of land in an 8-inch rainfall area amounts to 217,248 gallons. This is enough to supply water to more than 200 head of cattle for 100 days. This study includes the development and testing of materials for ground covers and storage facilities to be used for the collection and storage of water in low rainfall areas together with the design and operation of these facilities.
- (g) Butyl sheeting and asphalt-coated prefabricated structures still appear to be the most promising materials for ground covers. Storage of the water collected in closed bags completely eliminates losses from seepage and evaporation.
- (h) "Collecting Desert Rainfall," by C. W. Lauritzen, Crops and Soils, Vol. 13, No. 9, pp. 7-8, Aug. - Sept. 1961.

(3874) INFLUENCE OF COLORADO RIVER WATER UPON IRRIGATION AND DRAINAGE IN THE SAN JACINTO BASIN, CALIFORNIA.

- (b) Laboratory project.
- (c) V. S. Aronovici, Research Soil Scientist, P. O. Box 629, Pomona, California.
- (d) Experimental.
- (e) A study of the use of Colorado River water for irrigation applicable to the intermediate valley and plains areas of southern Calif. is being conducted in two ways. First, in 1954 a group of key soil sampling stations were selected and sampled annually. The soil analyses were compared with previous analyses, annual rainfall patterns and cropping practices. The second study, initiated in 1960, encompasses an elaborate plot program in which potatoes and grain are grown in a three-year rotation. One-half of the plots were presalinized. Only sufficient water to supply evapotranspiration was applied to one group of plots while to the second an excess of 20 percent evapo-transpiration demands is applied.
- (f) Both phases of this study are active.
- (g) Key salinity trend stations have revealed during the past ten years that soil salinity has increased gradually in areas irrigated with Colorado River water. Winter rainfall

has a very marked influence upon this rate of accumulation. A winter of substantially above normal rainfall will do much to leach the accumulated salts from the soil. However, on an average annual basis rainfall is not a dependable means of leaching. Consequently, the farm operation must include a leaching program as part of the irrigation practice. The plot studies have, in the first season, indicated the influence of but moderate concentration of salts upon productivity.

(4358) FLOOD WAVE MOVEMENT AND ROUTING IN ALLUVIAL CHANNELS.

- (b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.
- (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
- (d) Experimental; field and laboratory.
- (e) Tandem gaging stations supplemented by continuous water level records at 2,000 foot intervals between stations are utilized to study the movement of flood waves generated by cloudburst type thunderstorms through natural channels. Ultimate objective is to devise suitable analytical routing techniques for use with this type of flow.

(4359) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM SEMI-ARID WATERSHEDS.

- (b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.
- (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
- (d) Experimental; field and laboratory.
- (e) Rainage networks with a density of one per square mile are being operated on the 58-square mile Walnut Gulch Watershed in southern Arizona and the 67-square mile watershed in eastern New Mexico. Objectives of the study are to determine precipitation parameters of importance in determining runoff and sediment yield, and to give particular attention to the small highly intense convective summer thunderstorms typical of the region.
- (g) Return frequencies on the Walnut Gulch Watershed, computed from three years of record for 55 rainages, were identical with those computed from 61 years of record at a point located near the center of the watershed. This lends credence to the hypothesis that convective thunderstorm cells occur in a random fashion. Nearly half of the summer storms were composed of more than one cell. Eighty percent of the convective cells covered areas less than 4.5 square miles. On the Alamogordo Creek Watershed, a convective thunderstorm occurred which had intensities for time intervals up to 30 minutes greater than any reported by first order Weather Bureau Stations in the United States. 2.03 inches fell in 5 minutes, and 3.09 inches were recorded in 15 minutes.
- (h) "Some Properties of Precipitation Associated with Runoff from Walnut Gulch Watershed, Arizona," by Joel E. Fletcher, Amer. Geophys. Union Trans. (In press).
"A Record Storm Event on the Alamogordo Creek Experimental Watershed in Eastern New Mexico," by R. V. Keppel, Amer. Geophys. Union Trans. (In press).

(4360) RUNOFF FROM COMPLEX WATERSHEDS AS INFLUENCED BY CLIMATIC AND WATERSHED CHARACTERISTICS.

- (b) Laboratory project, cooperative with the Arizona and New Mexico Agric. Expt. Stations.
- (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
- (d) Experimental; field and laboratory.
- (e) On watersheds up to 43,000 acres in size records are maintained and procedures are being developed for combining flows from unit source areas to produce hydrographs of

stream flow on large complex watersheds, and to determine the effects of watershed characteristics and treatments on rates and amounts of runoff and net yield of usable water. A new design of critical depth flume with capacities up to 18,500 cfs is being used to measure runoff from the flashy, sediment laden flows characteristic of the region.

- (g) On the Walnut Gulch Watersheds, annual water yield decreases exponentially with the 0.3 power of the area. All of the water yield to date has resulted from summer convective thunderstorms during the June-September period. Transmission losses in the channel system exert a profound effect on both the water yield-area relation and on hydrograph characteristics. On the 67-square mile Alamogordo Creek Watershed, hydrographs having peaks in excess of 1,000 cfs have exhibited a flat top characteristic of 2 to 3 hours duration, which is believed due to very large valley storage above an abrupt discontinuity in the channel system.
- (h) "Some Research Findings on the Alamogordo Creek Experimental Watershed," by R. V. Keppel and J. L. Gardner, Proc. of the Fifth Annual N. Mex. Water Conf., 1960, p. 19.
"Water Yields from Southwestern Grassland," by R. V. Keppel, for publication by Sul Ross College, Alpine, Texas. (In press.)
"Watershed Research on Semi-Arid Rangelands," by R. V. Keppel, Proceedings Fifth Annual Arizona Watershed Symposium, Sept. 1961, pp. 33-35.

(4361) THE ROLE OF VALLEY AND CHANNEL MATERIALS AND VEGETATION IN THE HYDROLOGY OF SEMI-ARID WATERSHEDS.

- (b) Laboratory project, cooperative with the Arizona and New Mexico Agric. Expt. Stations.
- (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
- (d) Experimental; field and laboratory.
- (e) Records from tandem gaging stations are utilized to evaluate the losses which occur as runoff traverses ephemeral stream channels. Moisture measurements in the channel alluvium and records from shallow wells permit evaluation of depletion patterns and moisture disposition by evaporation and riparian vegetation.
- (g) Transmission losses up to 25 acre feet per mile have been measured on a four-mile reach of channel at Walnut Gulch Watershed. Reduction in water yield per unit area with increasing drainage area is due in large part to transmission losses. Much of the water entering channel alluvium as transmission loss is dissipated by direct evaporation or by transpiration by riparian vegetation.
- (h) "Transmission Losses in Ephemeral Stream Beds," by R. V. Keppel and K. G. Renard, presented to A.S.C.E. Annual Meeting, 1961. (In press).

(4362) THE HYDROLOGY OF SEMI-ARID WATERSHEDS AS INFLUENCED BY CHARACTERISTICS OF SOIL AND VEGETATION.

- (b) Laboratory project, cooperative with Arizona and New Mexico Agric. Expt. Stations.
- (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
- (d) Experimental; field and laboratory.
- (e) The interrelations of native vegetation and soils and their influence on water and sediment yields are being evaluated on rangeland watersheds in Arizona and New Mexico from 100 to 43,000 acres in size. Supplementary to the vegetation and soil studies on the watershed entities, 6 x 12' infiltrometer plot studies are being initiated. A primary objective of these studies is to determine the precision of sampling necessary to allow detection of differences in vegetation and soils which will affect water and sediment yield.

- (4363) HYDROLOGIC DATA REDUCTION WITH ANALOG-TO-DIGITAL CONVERTER.
- (b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.
 - (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
 - (d) Experimental; field and laboratory.
 - (e) Hydrologic records in analog form are being reduced to digital form by means of analog to digital converters. Information is transferred directly from rainfall and water level strip-charts to punched cards. Both semi-automatic converter techniques are being utilized.
- (4364) RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE AREA WATERSHEDS AS INFLUENCED BY MICRO-CLIMATE, WATER BALANCE, SOIL AND VEGETATION.
- (b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.
 - (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
 - (d) Experimental; field and laboratory.
 - (e) Runoff and sediment yields are being measured on several single-cover, single-soil subwatersheds located within large complex experimental watersheds. Objectives are to evaluate the effects of various soil-native vegetation complexes and microclimatic factors on local runoff, water yield and sediment movement, and to determine the effects of water balance of component parts of soil and vegetation, i.e. grass and brush, on local runoff and sediment production.
 - (g) Predominantly brush covered subwatersheds have produced approximately four times as much sediment as grass covered areas, with very little difference in water yield.
- (4365) SEDIMENT MOVEMENT ON COMPLEX WATERSHEDS AS INFLUENCED BY CLIMATE AND WATERSHED CHARACTERISTICS.
- (b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.
 - (c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
 - (d) Experimental; field and laboratory.
 - (e) Objectives of this study are: (1) To determine the relationship of sediment production from unit source areas to its movement in channels and to sediment yield from complex watersheds; (2) to adapt or develop methods for measuring sediment concentrations in the heavy silt-laden ephemeral streams of the Southwest; (3) to determine the rate and influencing factors in the sedimentation of stock watering ponds; and (4) to develop methods for reducing sediment yield from a complex watershed. Laboratory investigations are being conducted with an electrical capacitance method of sensing sediment concentrations.
- (4366) RAINFALL CONTRIBUTION TO GROUND WATER SUPPLIES AT SELECTED SITES IN SANTA BARBARA COUNTY, CALIFORNIA.
- (b) Laboratory project, cooperative with Santa Barbara County Water Agency; U. S. Geological Survey; California State Department of Water Resources; and U. S. Bureau of Reclamation.
 - (c) Mr. G. L. Lawless, Soil Scientist, P. O. Box 3, Lompoc, California.
 - (d) Basic and applied research.
 - (e) Soil moisture measurements (made with neutron scattering moisture meters to depths of ten to twenty-eight feet) together with measurements of precipitation and other climatological factors are being made to determine how much, if any, of the rainfall in certain ground water recharge areas penetrates beyond the root zone. The thirteen sites being studied represent various cover, soil, and topographic conditions. From the data collected, evapotranspiration rates are determined. A study is made of movement of water in various soils to help determine net contribution to ground water recharge by deeply penetrating rainwater.
- (4367) CONSUMPTIVE USE OF WATER AS RELATED TO PACIFIC COASTAL CLIMATIC INFLUENCE.
- (b) Laboratory project, cooperative with Santa Barbara County Water Agency; U. S. Geological Survey; California State Department of Water Resources; and U. S. Bureau of Reclamation.
 - (c) Mr. P. R. Nixon, Agricultural Engineer, P. O. Box E, Lompoc, California.
 - (d) Basic and applied research.
 - (e) Soil moisture and soil suction measurements are made on land in native vegetation and agricultural crops under central California coastal and nearby environments. From these and other data, evapotranspiration is computed. Evapotranspiration values are compared with observations made at five climate stations of USWB Class A type. Objectives include basic information and refinement of present methods of computing evapotranspiration, for development of improved management techniques for agricultural watersheds and associated ground water basins along the coast.
 - (g) Rather marked increase in evapotranspiration rates have been observed as distance increases from four to twenty-eight miles from the ocean. These rates are noticeably related to measurable climatic factors. Summarizing report of five years of field observations is in process of preparation.
- (4368) DEVELOPMENT OF A PORTABLE IRRIGATION SPRINKLER EVALUATION DEVICE.
- (b) Laboratory project.
 - (c) Mr. Rhys Tovey, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.
 - (d) Experimental; applied research.
 - (e) (1) To develop a portable device that can be used in design and evaluation of sprinkler irrigation systems; and (2) to determine procedures for the use of the portable irrigation sprinkler evaluation device in measuring soil intake rates, sprinkler application rates and other factors pertinent to the efficient design of sprinkler irrigation systems.
 - (g) A portable irrigation sprinkler evaluation device has been designed and constructed. Preliminary tests show that the device works satisfactorily.
 - (h) "A Portable Irrigation Sprinkler Evaluation Device," by Rhys Tovey, paper presented at the winter meeting of American Society of Agricultural Engineers, Dec., 1961, and submitted for publication in ASAE Journal or Transactions.
- (4369) ANALYZING RISE AND FALL OF GROUND WATER MOUNDS WITH A RESISTANCE NETWORK ANALOG.
- (b) Laboratory project.
 - (c) Dr. Herman Bouwer, Soil Scientist, Water Conservation Laboratory, Route 2, Box 816-A, Tempe, Arizona.
 - (d) Theoretical, development of analog techniques.
 - (e) A technique for analyzing ground water mound behavior under recharge areas is developed. The technique is applicable to stable,

- rising, or falling mounds, to two-dimensional or radial flow systems, and to uniform or non-uniform conditions of soil and recharge rates. Equations are derived for estimating rates of rise or fall of the center region of the mound.
- (f) Completed.
- (g) The technique for analyzing ground-water mounds enables taking into account conditions of non-uniformity in soil conductivity, porosity, and recharge rates as well as complex geometry, boundary, and drainage conditions. Moving mounds are handled as a succession of stable mounds. The technique may be used in planning, designing, or analyzing actual installations, which requires adequate field data, or for studies of a general nature where assumed values may be employed. Approximate equations are developed to predict the rate of rise or fall of the mound center above an original water table. Comparison of these equations with network analyses for two-dimensional rising mounds shows a good agreement if the width of the recharge area is less than four times the depth of the originally saturated material. Application of the horizontal-flow assumption and associated use of the transmissibility coefficient in analytical treatment of ground-water mound behavior can lead to serious errors. It is shown that this assumption can overestimate or underestimate the rate of rise of a mound, depending on whether the original depth of saturated material is relatively small or large, respectively.
- (h) "Analyzing Ground Water Mounds by Resistance Network," by Herman Bouwer. Jour. Irrig. and Drain. Div., Proc. Amer. Soc. Civil Eng. (submitted for publication).
- (4370) USE OF SEEPAGE METERS IN CANAL LEAKAGE AND GROUND WATER RECHARGE INVESTIGATIONS.
- (b) Laboratory project.
- (c) Dr. Herman Bouwer, Soil Scientist, Water Conservation Laboratory, Route 2, Box 816-A, Tempe, Arizona.
- (d) Theoretical and field investigations.
- (e) A variable-head technique for seepage meters is developed which eliminates pressure differences between the seepage cup and the canal as a source of error. In addition to the seepage, the method also furnishes information regarding hydraulic conductivity of bottom material and seepage gradients. Suitable field equipment has been constructed and tested in connection with seepage and recharge studies. The effect of velocity in the canal on the local head environment of seepage meters and on seepage as such was studied in a laboratory flume.
- (f) Completed.
- (g) Velocity in a canal did not have a direct effect on seepage rates. The velocity caused the average pressure environment of a seepage cup to be slightly below the free water surface. Correction factors for this effect were developed with a model study. The equipment for the variable-head technique for seepage meters includes a vacuum manometer, so that the measurements can be conveniently taken on the canal bank. Water level fluctuations during the period of measurements cause no interference. The seepage meters can be used to measure local seepage rates and permeability conditions of bottom material. This information can be useful in: (a) locating leaky sections in a canal; (b) checking logging techniques for seepage evaluation; (c) detecting presence of seepage restricting seals; (d) estimating effect of lowering of water table on canal seepage; and, (e) determining most effective measures to increase recharge from ground water recharge installations.
- (h) "A Variable Head Technique for Seepage Meters," by Herman Bouwer. Jour. Irrig. and Drain. Div., Proc. Amer. Soc. Civil Eng. 87 IR 1: 31-44, 1961.
- (4371) A DOUBLE-TUBE METHOD FOR MEASURING HYDRAULIC CONDUCTIVITY OF SOIL IN SITU ABOVE A WATER TABLE.
- (b) Laboratory project.
- (c) Dr. Herman Bouwer, Soil Scientist, Water Conservation Laboratory, Route 2, Box 816-A, Tempe, Arizona.
- (d) Laboratory and field studies, development and evaluation of a technique.
- (e) See (g).
- (f) Completed.
- (g) A method for measuring hydraulic conductivity K of soil in situ above a water table is presented. Two concentric tubes are placed in an auger hole and filled with water to saturate the soil below the bottom of the hole. The inner tube penetrates the soil a distance of approximately one inch. Hydraulic conductivity is calculated from the flow between the two concentric tubes through the soil below the auger hole due to different water levels in the tubes. This flow is evaluated by carrying out certain falling water-level measurements in the inner tube. Dimensionless parameters are used in calculating the conductivity. These parameters are a function of the geometry of the installation and were evaluated with a resistance network analog. Field equipment for the double-tube method includes a special hole-cleaner to reduce disturbance of soil at the bottom of the auger hole, and to obtain a "clean" soil surface. The time of sufficient depth of saturation below the auger hole, as evidenced by consistent K-values from successive measurements, can be ascertained in the field without having to calculate K after each set of measurements. Results from the double-tube method compared favorably with conductivity data obtained from soil samples in field studies, and with a known conductivity value in a laboratory study using a sand box. The double-tube method is free from stringent assumptions and simplifications. Air entrapment and non-uniformity or anisotropy within the soil region from which K is determined are the major sources of uncertainty. The geometry of the flow system from which K is evaluated is well defined. The method appears to be a suitable tool for field measurement of hydraulic conductivity of soil that is not saturated prior to the time of the measurement.
- (h) "A Double-Tube Method for Measuring Hydraulic Conductivity of Soil in Situ Above a Water Table," by Herman Bouwer. Soil Sci. Soc. Amer. Proc., Vol. 25, pp. 334-339, 1961. "Field Determination of Hydraulic Conductivity Above a Water Table with the Double-Tube Method," by Herman Bouwer. Soil Sci. Soc. Amer. Proc. (submitted for publication). "Application of the Double-Tube Method for Field Measurement of Hydraulic Conductivity of Soil Above the Water Table," by Herman Bouwer. Agricultural Engineering (submitted for publication).
- (4372) FIELD INVESTIGATIONS OF SEALING IRRIGATION CONVEYANCE CHANNELS WITH SEEPAGE TRANSPORTED BENTONITE.
- (b) Laboratory project.
- (c) Mr. Myron B. Rollins, Soil Scientist, Agricultural Research Service, Box 8014, University Station, Reno, Nevada.
- (d) Experimental, applied research.
- (e) To study on a field basis, the adaptability

and the physical and economic feasibility of sealing irrigation conveyance channels with bentonite. This will include developing and testing sealing procedures. Also to determine, and define, some of the limitations of bentonite sealing as influenced by the physical, chemical, and mineralogical properties of sand, water, and bentonite.

- (g) One year of research has shown that a substantial reduction of canal seepage rates can be accomplished with bentonite treatments.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Central States Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. R. D. Lane, Director, 111 Old Federal Bldg., Columbus 15, Ohio.

(3563) SUBSOIL WATER MANAGEMENT ON NORTHERN HARDWOOD FOREST AREAS.

- (g) The technique of inserting plastic into the vertical, downslope face of subsoil water movement study plots--to lead subsurface stormflow into collector troughs--has been amended because we suspected that a heavy flow, which seemed to be coming from fine-textured layers deep in the profile, was caused by an unnatural drawdown at the face of the plot. This has been corrected by using a step-system at the downslope face. Flow from the different depths now seeps outward through the downslope plot face into a collector trough or percolates downward and goes through four additional inches of soil into the next deeper trough. The resistance of the additional soil below each trough causes almost all the flow above the trough to exit from the plot face into that trough. With this step down trough placement system flows do not occur from troughs that are as deep as 120 c.m. We are now using standard multiple mercury-manometer tensiometers on our plots. They are quite accurate and are sensitive to small soil moisture changes. On this summer's plot studies they show that a temporary ground water table builds up during the time water is being applied. Flow from specific depths appears and continues as long as the tension of that depth is approaching zero, is at zero, or is below zero (positive piezometric pressure). After water application is stopped, soil moisture tensions in the surface soil rise quickly to above zero and flow from the shallower depths ceases. Flow continues from the lower depths as long as the tension there is at or below zero.

(4373) USE OF NUCLEAR RADIATION EQUIPMENT FOR MEASURING FOREST SOIL MOISTURE AND DENSITY.

- (b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Some newly developed equipment, operating on the principle of nuclear radiation, facilitates the measurement of soil moisture and the soil's closely allied property--bulk density. We now have a five-piece set of this nuclear radiation equipment. We are investigating principles that will guide us in the use of this equipment.
(g) 1) Single one-minute readings are adequate for our subsurface moisture probe. 2) Recalibration of our subsurface moisture probe gave a curve that crossed the one furnished by the manufacturer. 3) Recalibration of our surface moisture probe produced a linear calibration curve that extended through the origin, but was significantly lower than the manufacturer's curve. Anyone acquiring a surface moisture probe should run a cali-

bration check for his conditions. However, the linearity of our curve, its passage through the origin, and its close fit mean that only a relatively small number of calibration samples should be necessary.

4) When the soil was dry the surface moisture meter probed through a thicker layer of soil than it did when the soil was wet. For instance, at 39.9 Pv (percent by volume) the effective thickness was 7-inches; at 22.5 Pv it was 9-inches, and at 11.3 Pv it was 10-inches. 5) The saturation point of our Muskingum silt loam is probably somewhere near 50 Pv, but our nuclear equipment will not indicate when a soil has reached its saturation point. Increasing the moisture content beyond this point results in a replacement of some of the soil particles with moisture particles. A maximum number of neutron counts per minute will not occur until all the soil particles are replaced by water. A water film at least 4 inches thick would be required before our surface probe would give its maximum reading. 6) When a surface moisture probe is to be used on a shallow soil, the depth from surface to bedrock must be known. If the soil is less than 8-inches thick, it would appear necessary to run a separate calibration for that particular soil on its underlying material. 7) Our surface moisture probe must be used on a smooth surface because its counting rate decreased as an air space between meter and soil surface increased.

The greatest decrease in counting rate per unit of air space occurred at the highest level of soil moisture and the least occurred for the lowest level of soil moisture. For example, a 0.25-inch air space over 11 inches of soil caused the meter to indicate 3.7 Pv less moisture when the soil was wet and 0.8 Pv less when the soil was dry. 8) Two inches of pine needles between our surface moisture probe and the soil surface exerted the same influence as two inches of air space. Therefore, it would be impractical to make readings with the meter placed loosely on top of the forest floor. Litter accumulation, organic matter decomposition and changes in the "springiness" of the forest floor with changes in moisture content might cause the meter to have different amounts of air space between it and the soil at different reading dates. 9) Incorporation of decomposed organic matter into the surface soil had no detectable influence upon the surface meter's counting rate. 10) Type of access tubing affected both subsurface density and subsurface moisture readings, but the effect on density was the reverse of that on moisture. For example, if the moist bulk density of our gravimetric field sample is taken as 100, then the moist bulk density in aluminum, seamless steel and electric metallic tubing was 102.4, 125.9, and 129.5, respectively. Whereas, with the gravimetric moisture content as a base of 100, that in aluminum tubing was 142.3, seamless steel was 134.6 and electric metallic tubing was 115.4.

(4374) USE OF EXTERIOR PLYWOOD AS CUTOFF WALLS FOR TEMPORARY WEIRS ON SMALL FORESTED WATERSHEDS.

- (b) Laboratory project.
(d) Experimental and field investigation, applied research.
(e) Standard exterior plywood (5-ply) and exterior plywood (5-ply) overlaid on both sides with impregnated paper are being tried as cutoff walls for temporary weirs. They are being used in place of concrete where the trouble and expense of building permanent stream gaging structures may not be warranted and where there is little sediment and debris.
(g) We have used plywood cutoff walls success-

fully for 24 months on two 20-acre forested watersheds in Eastern Ohio. These watersheds are located in a well protected hardwood forest. The stream channels are well stabilized and low flow prevails throughout most of the year. Ninety-degree, sharp-crested blades on the plywood walls assure sensitive, low-flow measurements. So far, the maximum flow has been 70 c.s.m. (cubic feet per second per square mile), 1-foot stage and the minimum flow has been 0.005 c.s.m., 0.02-foot stage. Volumetric measurements of discharge, made down to 0.04-foot stage, checked closely with the theoretical values given by the equation:

$$Q = 2.5H^{2.47}$$

where Q is discharge in cubic feet per second and H is stage in feet. To us this implies that the friction coefficient of our plywood cutoff wall is similar to that of the material used in deriving the original weir equation.

- (h) "Plywood Cutoff Walls for Temporary Weirs," by Ronald Z. Whipkey, Station Note No. 150, Central States Forest Experiment Station, Forest Service, United States Department of Agriculture, Columbus, Ohio, August 1961, 2 pp.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Intermountain Forest and Range Experiment Station,
Ogden, Utah.

Inquiries concerning projects should be addressed to
Dr. Reed W. Bailey, Director, Intermountain Forest
and Range Experiment Station, Ogden, Utah.

(4375) STUDIES OF SUMMER STORM CHARACTERISTICS IN
THE INTERMOUNTAIN REGION.

- (b) Laboratory project.
- (d) Experimental and field investigations; basic and applied research.
- (e) Study of occurrence, duration, and intensity of summer storms in the Intermountain Region.
- (g) Analyses of summer storm characteristics during the past 19 years at three stations in northern Utah that ranged in elevation from valley to mountaintop revealed that rainfall began at all hours during the day and night. A slight majority of storms began during the period from 6 pm to 6 am. The least number of storms occurred during the period from 6 am until noon. For 19 years at Farmington (elev. 4,334 ft.), 210 summer storms produced total precipitation of 37.47 inches. This amount fell during a period of 350 hours at an average rate of 0.107 in. per hr. At Rice station (elev. 6,880 ft.) and Parrish (elev. 8,200 ft.) average seasonal precipitation rates were 0.105 and 0.102 in. per hr., respectively, indicating little variation in average storm intensity with elevation. Intensity of individual storms varied markedly, however. In southern Idaho, high intensity storms occur mostly during the period May through September. Precipitation exceeding infiltration capacities of depleted rangeland occurred for 1-, 2-, 3-, 5-, 7-, 8-, 10-, 15-, and 20-minute periods since records were commenced in 1936. The damaging effects of high-intensity storms are most severe on areas bared of vegetation by logging or where excessive grazing and trampling have depleted ground cover.
- (h) "High-Intensity Rainstorms on the Boise and Payette National Forests," W. J. Kidd, Jr., Intermountain Forest and Range Experiment Station Research Note No. 81, 4 pp., 1961.

(4376) HYDROLOGIC PHENOMENA ON SNOW-COVERED AND
FROZEN TERRAIN IN THE EAST SIERRA NEVADA.

- (b) Laboratory project.
- (d) Experimental and field investigations; basic and applied research.
- (e) To determine the effects of vegetation, litter cover, and exposed rock on infiltration, overland flow, and soil loss from snow-covered and frozen terrain in the east Sierra Nevada.
- (g) Six pairs of plots were established to represent a range of forest floor conditions in a young Jeffrey pine stand. One condition was modified by superimposing shallow contour furrows across slope. The study consisted of three phases: a summer operation and two winter tests. Relation of minimum infiltration rate (1 to 2 hrs. after beginning of simulated storm) to summer and winter ground surface conditions was determined by regression analysis. Expression of the dependent variable infiltration (I_m) in inches per hour to ground cover (V_e) in percent, to the absence or presence of contour furrows (C_f), to type of soil frost ($F_s(b)$), and to season of year (S_e) is given by the equation

$$I_m = 0.707 + 0.00423 V_e \\ + 0.321 C_f - 0.166 F_s(b) - 0.091 S_e$$

with the standard error of estimate being 0.17 inch per hour. The four regression coefficients, except season of year, are significant at the 1-percent level. The equation indicates that variation in ground surface characteristics explains 96 percent of the variation in apparent minimum infiltration rate. If soil frost is of the stalactite form, water intake exceeds that under the porous concrete type of frost. The relation of soil erosion from infiltrometer plots to ground surface condition was determined in a similar manner. Average soil erosion rate (E_r) in relation to overland flow (O_f), exposed rock (R_e), snow cover index (S_n), type of soil frost ($F_s(a)$), and contour trenches is represented by the equation

$$E_r = 27.373 O_f + 2.734 R_e - 0.102 S_n \\ - 5.018 F_s(a) - 19.160 C_f - 26.003$$

with the standard error of estimate being 16.2 tons per square mile per hour. Regression coefficients for overland flow, exposed rock, and snow cover index are significant at the 1-percent level; the other two variables at the 5-percent level. Variation in these parameters explains 82 percent of the variation in soil loss.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Lake States Forest Experiment Station.

Inquiries concerning the following projects should be addressed to the Director, Lake States Forest Experiment Station, St. Paul Campus, University of Minnesota, St. Paul 1, Minn., unless indicated otherwise.

(3886) THE CLASSIFICATION AND NOMENCLATURE OF
NATURAL UPLAND FOREST HUMUS TYPES IN THE
NORTHERN LAKE STATES.

- (b) A regional cooperative project with the Department of Forestry, Michigan State University, East Lansing, Mich.
- (c) Dr. D. P. White, Department of Forestry, Michigan State University, East Lansing, Mich.
- (d) Field investigation; basic and applied research.
- (e) The various types of humus layers in Michigan, Wisconsin, and Minnesota forests are to be classified and checked against the existing humus classification by Lunt and Hoover.

(3887) WATERSHED MANAGEMENT RESEARCH IN NORTHERN MINNESOTA.

- (b) Laboratory project.
- (d) Experimental and field investigations; basic and applied research.
- (e) Tests the influence of forested bogs on streamflow and groundwater behavior. Three major projects have been undertaken to date:
 - 1) Studies of the effect of forest cover conditions on individual hydrologic processes. This has included the impact of soil-cover types on snow accumulation and melt, soil freezing, and moisture regime.
 - 2) Studies of forest bog hydrology on small forested swamp watersheds. Present instrumentation includes a recording well and a series of 9 to 12 nonrecording wells in each of 5 swamps. Four swamp watersheds have been equipped with stream-gaging stations and rain gages.
 - 3) Laboratory studies of the moisture storage characteristics and other related physical properties of peat soils. Moisture characteristics of undisturbed peat cores are being determined with specially built pressure cells.
- (g) Early records indicate the magnitude of swamp water table fluctuations are related to rainfall and depth of the water table below the surface. This is due to the layered peat soil. When the water table was near the surface, light summer rains of 0.1 to 0.35 inch caused the water table to rise from 0.5 to 1.45 inches, or roughly a 4 to 1 ratio of water table rise to rainfall. Recording wells indicate that some swamp water tables drop over 2 feet during the winter, reaching a low point just before snowmelt begins. Laboratory studies of undisturbed peat cores indicate the ratio of change in water table elevation to the depth of water added or drained from the core varies from 5 to 1 for undecomposed sphagnum peat to over 100 to 1 for moderate to well decomposed sedge peat 50 to 60 cm. below the bog surface.
- (h) "How Much Water in a Swamp," by Roger R. Bay, Minn. Conserv. Vol. 24(143): 48-51, illus., 1961.

(3889) WATERSHED MANAGEMENT RESEARCH IN THE DRIFTLESS AREA OF SOUTHWESTERN WISCONSIN.

- (b) Laboratory project, with some aspects in cooperation with Wisconsin Conservation Dept.
- (d) Field investigations; basic and applied research.
- (e) Major emphasis is given to methods of controlling runoff and erosion, including gully stabilization through reforestation, and other land-use treatments. Studies of infiltration, soil-moisture movement and storage on loessal soils under the impact of grazing and other uses are planned. The effect of land use and land treatments on springflow is also being investigated. In connection with this, ground-water divides are being mapped by subsurface exploration. A total of 25 water-measuring devices have been installed on watersheds ranging from about 2 to 55 acres in area. The devices include 90 V-notch weirs, modified 2-foot San Dimas flumes, and several sizes of H-flumes. All are equipped with recording instruments.
- (g) In connection with studies of soil-moisture storage, a Nuclear-Chicago neutron-scattering soil-moisture meter (Model P-19) was field calibrated against gravimetric samples in silt loam loess soils over a range of moisture content from 5 to 39 percent by volume. For the particular probe involved in the study, it was found the calibration curve furnished by the manufacturer gave an estimate of moisture content that was about 2 percent higher (by volume) at 10-percent moisture and 2 percent lower at 30-percent moisture. Differences increased beyond these extremes, and decreased to zero at 21 percent.

An air-photo study of 40 completely forested watersheds in the Driftless Area near La Crosse, Wis., showed no gullying nor other signs of surface flow, thus indicating the high infiltration rate of forest land. Where gullies are present in forest land, they have been caused by runoff from higher lying agricultural land.

A sample inexpensive point gage has been devised of aluminum to measure water level at stream gaging stations.

- (h) "Comparison of Bulk Density of Soil in Abandoned Land and Forest Land," by Richard S. Sartz, Lake States Forest Expt. Sta. Tech. Note 601, 2 pp., 1961.
- "The Forest-Land Gully in the Driftless Area--Natural or Man-Caused," by Richard S. Sartz, Lake States Forest Expt. Sta. Tech. Note 612, 2 pp., illus. 1961.
- "An Inexpensive Water-Level Point Gage," by Willie R. Curtis, Lake States Forest Expt. Sta. Tech. Note 613, 2 pp., illus. 1961.
- "Field Calibration of a Neutron-Scattering Soil Moisture Meter," by Richard S. Sartz and Willie R. Curtis, Lake States Forest Expt. Sta., Sta. Paper 91, 15 pp., illus. 1961.
- "Soil Moisture Regime in Southwestern Wisconsin as Affected by Aspect and Forest Type," by J. H. Stoeckeler and Willie R. Curtis, Jour. Forestry 58: 892-896. 1960.

(3890) WATERSHED MANAGEMENT RESEARCH IN LOWER MICHIGAN.

- (b) Cooperative project with Fish Division, Michigan Dept. of Conservation, Lansing, Mich.
- (d) Field investigation; basic and applied research.
- (e) Two major projects have been undertaken to date: 1) A major study is designed to determine the hydrology of ground-water recharge and uses in deep sandy soils of the Udell Hills area in Michigan. Installations to date include a series of ground-water wells in deep morainal areas and adjoining outwash plains. After the calibration period, the effect of cover manipulation--especially plantation establishment and harvesting methods--on ground-water recharge and use will be established. 2) A second major study is concerned with streambank stabilization and the sediment problem in streams flowing through these sandy areas. Major objectives of this study are (a) to determine the influence of land use upon sediment production, and (b) to evaluate the effect of streambank stabilization measures upon suspended sediment loads. A total of 20 sampling stations have been established on the Tobacco River.
- (g) Ground-water recharge in a deep sand aquifer on a morainal hill shows a 6- to 8-week lag or longer between snowmelt (March 27-April 4) and rise of water table in 55- to 70-foot-deep wells; the wells, however, continue to recharge through July and into August. Shallow ground-water areas located under level outwash plains began to recharge no later than 2 weeks after snowmelt but reached their highest levels by late June or earlier.
- In the field of soil moisture sampling techniques, a study was completed near Wellston, Mich. The results indicate that the number of samples needed for an estimate of soil moisture will vary by soil depth and cover crop. Under both grass and oak cover types more samples are needed in the upper horizons. An oak plot should be more intensively sampled than a grass plot to achieve the same reliability of measurement. In the first foot of soil, about twice as many samples are needed under oak as under grass. At the 5- to 7-foot depth, only a 25-percent increase in sampling intensity is required.
- (h) "Intensity of Soil Moisture Sampling is

Affected by Depth and Vegetative Cover," by William D. Striffler, Lake States Forest Expt. Sta. Tech. Note 603, 2 pp., illus. 1961.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Northeastern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Dr. Ralph W. Marquis, Director, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pennsylvania.

(656) WATERSHED MANAGEMENT RESEARCH, DELAWARE-LEHIGH-EXPERIMENTAL FOREST, PENNSYLVANIA.

- (b) Laboratory project; in cooperation with the Pennsylvania Department of Forests and Waters and U. S. Geological Survey.
- (d) Field investigation; basic and applied research.
- (e) A study was started in 1948 on the Delaware-Lehigh Experimental Forest, Monroe County, Pa., to determine the water economy for a 1,530-acre watershed covered with scrub oak. The cover is now being converted by planting and fire protection to conifers and the effect on water relations will be measured. Suspended.
- (f) The watershed was calibrated on the basis of the first six years' daily climatic and streamflow record by relating monthly, seasonal, and annual discharge to rainfall air temperature. About 300 acres have been planted; further planting depends on results of seed-spot tests. Stream gaging and climatic research were discontinued December 31, 1958 until such time vegetation has changed sufficiently to warrant further gaging to determine the effect of the change on streamflow.
- (h) "Forest and Watershed Project. Delaware-Lehigh Experimental Forest, Report No. 4," by I. C. Reigner, W. E. McQuilkin, and E. F. McNamara, Pa. Dept. of Forests and Waters, Harrisburg, 97 pp., 1961.

(1188) WATERSHED MANAGEMENT RESEARCH, FERNOW EXPERIMENTAL FOREST, WEST VIRGINIA.

- (b) Laboratory project.
- (d) Field investigation; basic and applied research.
- (e) Studies were started in 1951 on the Fernow Experimental Forest, Tucker County, W. Va., to determine the effect of different levels of cutting practices, different logging methods, and different forest uses upon water quantity and quality. Nine watersheds have been equipped with streamgaging stations and rain-gages.
- (g) Following six years of record taking, and analysis for calibration, treatment of one group of five watersheds was started in May 1957 and completed in 1958. Records are being continued to determine treatment effects on streamflow.
- (h) "Automatic Devices to Take Water Samples and to Raise Trash Screens at Weirs," by K. G. Reinhart, R. E. Leonard, G. E. Hart, Northeastern Forest Expt. Sta. Note 112, 7 pp., 1961.

(2419) WATERSHED MANAGEMENT RESEARCH, HUBBARD BROOK EXPERIMENTAL FOREST, NEW HAMPSHIRE.

- (b) Laboratory project.
- (d) Field investigation; basic and applied research.
- (e) The objective is to determine the effect of forest type, condition, and treatment on quantity and quality of streamflow. Studies are conducted in plots and experimental watersheds on the 7500-acre experimental forest in the White Mountains at West Thornton, New Hampshire.
- (g) Six weirs have been built and climatic stations established.

- (h) "Net Precipitation in a Northern Hardwood Forest," by Raymond E. Leonard, Jour. Geophys. Res. 66: 2417-2421, 1961.
- "Interception of Precipitation by Northern Hardwoods," by R. E. Leonard, Northeastern Forest Expt. Sta. Paper 159, 16 pp., 1961.

(2910) WATERSHED MANAGEMENT RESEARCH, LEADING RIDGE WATERSHED, PENNSYLVANIA.

- (b) Laboratory project, in cooperation with the School of Forestry, Pa. State Univ. and the Pennsylvania Dept. of Forests and Waters.
- (d) Field investigation; basic and applied research.
- (e) A cooperative study was started in 1957 to determine the effect of forest cover and treatment on quantity and quality of streamflow in the oak-hickory type in Pennsylvania, and to study associated and basic soil-water relationships.
- (g) Six experimental watersheds have been selected weirs have been constructed, and climatic stations established.

(3567) WATERSHED MANAGEMENT RESEARCH, BALTIMORE WATERSHEDS, BALTIMORE, MARYLAND.

- (b) Laboratory project in cooperation with the Baltimore Bureau of Water Supply.
- (d) Field investigation; basic and applied research.
- (e) A cooperative study started in 1958 to determine effect of growth of loblolly and white pine in plantations on streamflow, and to compare streamflow from watersheds in conifer plantations with streamflow from a hardwood-forest watershed.
- (g) Streamflow of three experimental watersheds is being measured and a climatic station has been established.
- (h) "A City Manages Its Forested Watershed Lands," by Walter C. Sushko and Irwin C. Reigner, Jour. Soil and Water Conservation 16: 119-122, 1961.

(3568) WATERSHED MANAGEMENT RESEARCH, NEWARK WATERSHEDS, NEWFOUNDLAND, N.J.

- (b) Laboratory project in cooperation with the Division of Water Supply of the City of Newark, N. J., Newfoundland, N. J.
- (d) Field investigation; basic and applied research.
- (e) A cooperative study to determine the influence of selected treatments of forested municipal watersheds on water supply.
- (g) Weirs on 3 experimental watersheds were built in the fall of 1958 and stream gaging and climatic measurements were started in the spring of 1959.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Northern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Richard M. Hurd, Director, Northern Forest Experiment Station, Box 740, Juneau, Alaska.

(2654) EFFECT OF LOGGING ON PHYSICAL CHARACTERISTICS OF SALMON STREAMS IN SOUTHEAST ALASKA.

- (b) Laboratory.
- (d) Field investigation, applied.
- (e) This work is concerned with the relationships between salmon spawning streams and timber harvesting in Southeast Alaska. Work is concentrated on 4 streams lying 40 miles west of Ketchikan. One watershed has been logged; another will be cut over by the spring of 1962. Logging in a third watershed will not be completed for several years. The fourth watershed remains unlogged as a control. Study involves factors which may exert a major influence on pink and chum salmon

development and survival in a logged stream. Factors measured or sampled in 1961 are: 1) Stream discharges; 2) stream temperatures; 3) sediment movement in streams; 4) stream channel shift; and, 5) stream debris occurrence. Sediment movement studies expanded in 1960 were continued during the fall of 1961. Items 4) and 5), shown above were recorded by air photography during the summer of 1961. Additional work associated with items 3), 4), and 5) are reported as separate projects.

(4377) HISTORY OF SUSPENDED SEDIMENT IN A SALMON STREAM IN SOUTHEAST ALASKA AND EFFECT ON SALMON REPRODUCING ENVIRONMENT IN RIFFLE GRAVELS.

- (b) Laboratory project.
- (d) Experimental, basic and applied aspects.
- (e) This is a study of some features of suspended sediment behavior in salmon streams. Areas of chief concern are sediment drop-out from the stream and possible subsequent flush-out from the stream bed. Four stream riffles, each considered a potential chum salmon spawning area, were selected for study. One area is above a sector suitable for hydraulic mining sediment into the stream; the other 3 areas are downstream from the sediment source. The latter are treatment areas while the upstream area serves as control. Streambed gravels for each of the 4 study areas were sampled for composition prior to sedimenting the stream. Dissolved oxygen measurements were also taken at this time. The three downstream areas were then exposed to sediment-laden water for 6 to 8 hours a day for 10 days. Water was sampled with a hand sampler at the rate of 4 samples per hour during sedimentation. These samples were taken just upstream of the first treated study area. Discharge during the treatment period ranged from 9 to 24 cfs.; suspended sediment total load from 30 to 500 lbs. per hour. Total estimated suspended load during the 10 days of sedimentation was approximately 5-1/2 tons. During the sedimentation period, sediment samples were taken above and below several sections of the stream, in an attempt to locate the region of sediment drop-out and to estimate the rate of drop-out. Subsequent to sedimenting the stream, gravels in the stream beds at each of the 4 sample areas were re-sampled for composition and dissolved O₂. In the spring of 1962 it is planned to resample the streambed gravels to determine if the fall-winter freshets flushed the gravels and returned them to the pre-sedimentation condition. This is probably the most important question this study can help to answer.
- (g) Results will be available in 1962 after the stream bed is re-sampled.

(4378) EFFECTS OF LOG JAMS ON A STREAMBED.

- (b) Laboratory project.
- (d) Experimental, with both basic and applied aspects.
- (e) Study in cooperation with the Fisheries Research Institute of the University of Washington to determine the effects of log jams on pink and chum salmon spawning beds. Log jams were installed at two locations on a study stream (total watershed area 15.2 sq. mi.). In addition to being mapped in planimetric and topographic detail, the stream bed areas were sampled to determine gravel composition and dissolved oxygen level before log jam construction. Perforated ping-pong balls were also buried at 4 depths at a number of points in each area to determine the depth of bedload scouring.
- (g) Results will be available in 1962 after the

stream bed is remapped and resampled.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Northwest Forest and Range Expt. Station.

Inquiries concerning the following projects should be addressed to Mr. R. W. Cowlin, Director, Pacific Northwest Forest and Range Expt. Sta., P. O. Box 4059, Portland 8, Oregon.

(969) EFFECT OF LOGGING, CLEARCUTTING AND OTHER FOREST OPERATIONS ON STREAMFLOW.

- (b) Laboratory project.
- (d) Field investigation; applied research.
- (e) H. J. Andrews Experimental Forest, McKenzie River drainage, west central Oregon. Streamflow from three small experimental watersheds in virgin Douglas-fir has been measured for eight years by means of trapezoidal flume stream gages. These observations provide a pretreatment calibration which will be carried on for three years or more. Planned treatments will test effect of two systems of timber cutting on water yield and erosion. In 1959 logging roads were constructed in one of the three watersheds to supply information on sediment yields. Bull Run watershed in cooperation with City of Portland Water Bureau. Pretreatment calibration measurements now being taken on three small watersheds within the Bull Run watershed, source of Portland's water supply. Cover is virgin Douglas-fir. Streamflow is being measured by trapezoidal flumes. Results of this study will help determine the future management policy on the watershed. Entiat River drainage. Three small watersheds in granodiorite soils of north-central Washington are being studied. Streamflow is measured through 120-degree V-notch weirs, one completed in October 1959 and the remaining two in October 1960. Coyote Creek drainage. Two small watersheds in southwestern Oregon are being studied. Streamflow is measured through 120-degree V-notch weirs completed in September 1960.
- (g) Road construction in one of the watersheds in the H. J. Andrews forest exposed 6.2 percent of the watershed, and during three years following construction, roads were correlated with an increase in low flows and in suspended sediments. Timber removal in the Bull Run watershed has resulted in reduced draft of soil moisture during the growing season. Soils in clear-cut areas retained more moisture during the summer dry period and with the onset of fall rain, returned to field capacity status earlier than adjacent uncut areas.
- (h) "Pacific Northwest Forest & Range Expt. Station, Annual Report for 1960."

(2187) EFFECT OF CATTLE GRAZING ON EROSION.

- (b) Laboratory project.
- (d) Field investigation; applied research
- (e) Starkey Experimental Forest and Range, northeast Oregon. Study to determine the effect of heavy, moderate and light grazing on erosion, sediment production and runoff. Sediment catchment basins have been constructed in small drainages, one in each of six pastures in which are tested three rates of grazing and two systems of management: deferred-rotation and season-long use. Major effect on erosion will be determined by volume of sediment accumulated in the basins. Study now in its seventh year.

(2911) INFLUENCE OF FOREST COVER ON INTERCEPTION OF PRECIPITATION.

- (b) Laboratory project.
- (d) Field investigation; applied research.

- (e) H. J. Andrews Experimental Forest. A study of interception in old-growth Douglas-fir was begun in the summer of 1957. Net precipitation is measured by moving rain gages located at six representative sites; measurements of gross precipitation are being made in adjoining cutover areas.
- (g) Dense stands of virgin Douglas-fir intercept an average of 24 percent of summer precipitation (May-Sept.). Interception percent varies from nearly 100 percent during storms under .05 inches to 18 percent for 3-inch storms. During winter months, average interception drops to 13.7 percent. Only minor amounts of the intercepted precipitation reached the ground by stemflow.

(2912) EFFECT OF LOGGING ON EROSION.

- (b) Laboratory project.
- (c) Field investigation; basic and applied research.
- (e) Wenatchee River drainage, central Washington: Soils derived from three major parent materials were sampled and are being analyzed to determine their basic physical and chemical characteristics. Parent materials are Swauk sandstone, basalt and granite.
- Western Oregon and Washington: A reconnaissance survey was made of logging projects to determine the important sources of erosion and develop a program of research. Negotiations were completed for a study of Wyssen Skyline Crane logging on one of three experimental watersheds at H.J. Andrews Experimental Forest.
- (h) "Some Water Problems and Hydrologic Characteristics of the Umpqua Basin," by G. L. Hayes and H. G. Herring. Pac. NW. Forest and Range Expt. Sta. Misc. Paper, July 1960.
- "Surface Runoff and Erosion - Related Problems of Timber Harvesting," by Nedavia Bethlahmy. Jour. Soil and Water Conserv. 15(4): 158-161, July 1960.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Pacific Southwest Forest and Range Experiment
Station.

- (261) WATERSHED MANAGEMENT RESEARCH, SOUTHERN CALIFORNIA.
 - (b) Laboratory project.
 - (c) Dr. R. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
 - (d) Experimental; field investigations; basic and applied research.
 - (e) Purposes are 1) to determine how watersheds function: what happens to the precipitation, and how water and soil movement are influenced by conditions of vegetation, soil, geology, and topography; and 2) to develop methods of watershed management, including treatment of areas denuded by fire, to insure maximum yield of usable water and satisfactory flood runoff and soil erosion control.
- Principal work center is the 17,000-acre San Dimas Experimental Forest situated in the San Gabriel Mountains. A fire started by lightning in July 1960 consumed the vegetation, mostly brush, on 90 percent of the area and destroyed or damaged many of the research installations. Immediately after the fire a major emergency research program was started to test the effectiveness of various measures used to reduce flood runoff and erosion on the denuded watersheds. These rehabilitation measures include seeding grasses and mustard singly and in combination with physical treatments such as wattling, channel barriers and contour terraces. The tests are being made on 37

watersheds of 3 to 30 each, equipped to measure rainfall intensity, peak discharge and suspended sediment. Twenty-five have basins to measure bedload. Studies of hydrologic processes and tests of applied management methods to increase water yield through vegetative type conversion in progress before the fire are being continued.

(g) Good progress has been made in establishing studies of emergency first aid treatments to reduce flood runoff and erosion on San Dimas Forest watersheds denuded by fire last July. This progress has been covered in detail since last September in a series of special weekly reports to our cooperators and others directly concerned with the program. Highlights of these accomplishments are summarized here. Intensive tests of both vegetative and physical treatments are under way on 25 small watersheds of 2 to 8 acres each. A network of raingages has been installed on these watersheds and each has been equipped with a streamflow measuring flume, debris basin and suspended sediment sampler placed in the basin spillway. Five treatments, described below, have been applied individually or in combination on 24 of the watersheds. One watershed was left as the untreated control.

- 1) Annual grasses. A mixture of Wimmera rye and Blando brome grasses was broadcast sown in 9 watersheds--5 at 20 pounds per acre and 4 at 2-1/2 pounds.
- 2) Perennial grasses. Hardinggrass and pubescent wheatgrass were the principal species in a mixture with some annual broadcast sown at 20 pounds per acre in 4 watersheds and at 4-1/2 pounds in 4 others.
- 3) Side slope stabilization. Barley seed at the rate of 200 pounds per acre and fertilizer at 50 pounds per acre were placed in furrows on 2-foot contour intervals in 9 watersheds. This treatment involved planting more than 200 miles of furrows.
- 4) Contour basin-terraces. Large basin-terraces, a treatment developed by the Intermountain Region, were constructed with a heavy bulldozer in 9 watersheds. The terraces are spaced on contour 40 to 90 feet apart depending on slope. Their basins will store approximately 3 inches of precipitation on the area or debris at the rate of 500 cubic yards per acre.
- 5) Stream channel checks. Small dams less than 5 feet high were constructed of cement combined with soil and rock where available in 9 watersheds. These dams were located in the drainages so they would stabilize the channel bottom at about 7/10 of its former gradient.

The application of a chemical soil stabilizer was to have been included as a treatment on the small watersheds. A number of chemicals were checked in a laboratory test and several of these were further checked in an intensive field plot test. However, none of the chemicals was sufficiently promising to justify its use on a watershed. Black mustard compared to annual ryegrass as an emergency treatment on fire denuded areas is being tested on another series of 11 watersheds varying in size from 9 to 87 acres. Both high and low rates of broadcast seeding of each species are being tested. Raingages have been installed on the watersheds and each has been equipped with a flume for streamflow measurement and a suspended sediment sampler. All of the San Dimas Forest that was denuded by the 1960 fire, excepting the 36 watersheds included in the tests described above and others reserved as untreated controls, has been seeded to annual and perennial grasses. Thirteen thousand five hundred acres were sown by helicopter, 83 acres by hand and 29 acres by rangeland drill. These sowings include tests of individual species and mixtures of species for both emergency and permanent watershed cover.

The 1961 hydrologic year has been one of

extreme drought and record high rates of debris production on the San Dimas Forest. If the weather continues as it has so far, this will be the driest year in the history of the forest. Rainfall to April 1 totaled 9.36 inches; normally we would have 23.9 inches by this date. During the usually wettest months of December through March, rainfall amounted to only 3.51 inches. The 3-month drought period from December 2 to March 4 was broken by only one storm of 1.72 inches on January 25-26. This lack of rain has been a blessing and a curse to the emergency research program. It has given us respite in which to install new studies, and it has permitted us to obtain more debris production data in basins of limited capacity than would have been possible under a normal rainfall pattern. On the other hand, there have not been any large storms to test erosion control measures and the broadcast seeding has been severely blighted by drought. The planted barley is the outstanding exception. It has grown vigorously and is producing healthy heads of grain. Rates of debris production from the fire-denuded watersheds have been higher than ever recorded for any similar sized storms. The first storm of the winter season with only 1.02 inches of rain on the small Bell watershed, produced more than twice the pre-fire mean annual rate of debris from each of the watersheds. Debris production from Bell Watershed No. 1 during 4 storms, totaling 4.56 inches of rain, amounted to 12.14 cubic yards per acre--10.3 times the pre-fire mean annual rate.

Researchers at San Dimas are presently seeking a way of automating the analysis of precipitation data. Below is a brief description of the method that we currently favor. We would appreciate your comments on it and any information you might have on electronic data processing of precipitation records. The basic idea is to define a surface of precipitation in a three dimensional space. These three dimensions (x,y,z) are the location (x,y) of the point samples and the depth of rain (z) caught at each location. The points in space defined in this manner will serve to define a best fit precipitation surface through polynomial regression techniques. The volume above a given watershed--i.e., the volume bounded by the watershed boundaries, the map plane, and the precipitation surface would be found by multiple integration methods. The area of the watershed would also be found in this manner. The volume above the watershed divided by the watershed area is the estimate of the mean areal precipitation for that watershed. The same techniques would be used for all watersheds of interest on the map plane and under the precipitation surface. This method would be simple if all watersheds were flat as is the map plane. Because they are not, variables expressing this deviation from a plane should be considered in the definition of the precipitation surface. The precipitation falling at any given point is dependent on many factors. Those factors that are meaningful and definable, such as elevation, rise, slope, and aspect as defined by Burns as well as other factors that may be important, would be entered in the polynomial regression as independent variables to define the precipitation surface. In this manner it is hoped that a better fit of the surface and thus a more reliable estimate of areal mean precipitation will result. Secondly, it would provide a basis for estimating the reliability of a given rain-gage network density and a reasonable basis for its reduction or expansion. Chart readers are coming into use for processing streamflow data. At San Dimas we have been using a Gerber Digital X-Y chart reader connected to an IBM 026 key punch. As a result of this experience we are

confident that the Gerber machine is a most economic tool for processing our data. The Gerber X-Y reader has a two-axis reading system. This system consists of two basic components: The "scanner" which is a motorized chart transport, and the "reading head" which consists of two movable hair-lines (one for X and one for Y). The reading head allows read-out of a three-digit number with provision for a high order, fixed digit controlled by a 10 position switch for each axis. On each axis a zero setting may be made manually at any position on the chart. A sequence control was provided on the chart reader at our request which assures operation with a fixed sequence of reading: i.e., X,Y,X,Y. This eliminates one form of operator error--namely, two readings from one axis. The system has proven to be easy to operate and versatile in its application. We feel it is equal in quality to its much more expensive counterpart.

We have been using a card format of four reading points per card. Each point consists of an X and Y reading. To date we have read 43 station years of record with an average of 1200 to 1300 cards (5,000 point readings) per station year. Each station year requires about 20 hours reading time on the chart reader. This amounts to a reading cost (salaries) of about \$45 per station year. The machine is operated most of the time by GS-3 employees. An IBM 7090 computer program for reducing the data to instantaneous flows, mean daily flows, weekly flows, and monthly flows is in its last stages of de-bugging at this time. We plan to check the results using this new system with discharge that we had formerly computed using a Bendix G-15 computer with hand-tabulated data. When that is done we will be able to provide you with information of the precision and general functioning of our streamflow data reduction system. One hundred and seventy, fixed-stage suspended sediment samplers were installed in the burned-over watersheds of the San Dimas Experimental Forest as part of the emergency research program. All but 25 of these were patterned after the high-velocity sampler shown in the October, 1957 USGS report by J. C. Mundorff. In addition to these samplers storm duty crews took grab samples during storm runoff. The fixed-stage suspended sediment samplers were in and operating only for the last storm of the season. Due to the size of the storm only about 40 of the samplers had an opportunity to catch a suspended sediment sample. Only 6 samples were actually large enough to be analyzed. We are not satisfied that this sampler is suitable in our very turbid streamflow. The apparent cause for the failure of the high velocity sampler was the deposition of heavy sediments in the S-curved section before they entered the bottle. A secondary cause of failure was aggradation of the stream bottom above the sampler's intake before a sample could be obtained.

This summer we have been testing modifications of the high velocity sampler and the swing sampler developed by the Northeast Station. We found that the swing sampler works very well in our test flume. All of the samplers captured considerably less than the total sediment load. The catch ranged between 20 and 40 percent of flows carrying from 100-250 thousand parts per million (60 percent sand). Our grab samples indicate that this catch is a function of the stratum being sampled, not the configuration of the samplers. The samples taken in the field averaged about 137,000 parts per million (range: 3,000-401,000). Organic determinations were made on 6 of these 41 samples: the mean organic matter was 11 percent. Five samples were taken from a mud flow that preceded the peak in Volve Canyon. These samples ranged from

138,000 parts per million to 710,000 parts per million with an average of 417,000 parts per million. It's questionable whether this should be called suspended sediment but in all instances except the mud flow the fluid was behaving like water--very turbulent and traveling at velocities from 6 to 15 feet per second.

A study was undertaken to test several soil stabilizing chemicals for possible use in the emergency research program on the San Dimas Experimental Forest. We had planned to evaluate the ability of this treatment to reduce surface runoff and debris yield from some of our small study watersheds, but the tests did not justify watershed application. Nine chemicals were tested in the laboratory to determine their soil binding qualities. The products tested were: Formula -S developed at UCLA; Dupont's Elvanol; American Bitumal's and Asphalt's SS-2; Douglas Oil's SS-1; Douglas Oil's Docal 1002; Swift's 3876 SEC; Swift's Organic Base Size; Crown Zellerbach's Orzan A; and Crown Zellerbach's Orzan S. Three chemicals (Orzan S, Docal 1002, and Formula S) withstood the laboratory rainfall tests and exhibited good soil binding qualities. We decided to test them on field plots as a further measure of their effectiveness in controlling erosion.

The three more promising chemicals were sprayed on 6- x 40-foot plots on typically steep, fire-denuded slopes. Plots were equipped with border strips, and a catchment trough was installed at the bottom of each. Test runs on the treated plots and untreated controls were replicated 4 times. "Rainfall" was delivered to the plots through 3 sets of 5 rotating agriculture sprinklers. Measurements were taken of "rainfall", surface runoff, time of occurrence, total debris and suspended sediment. The result of the field tests indicated there was no significant difference between the treated and untreated plots. The thin crust of soil and chemical binder decreased infiltration rates and in turn increased surface runoff and debris production.

- (h) "Research and a Land Management Model for Southern California Watersheds," by Walt Hopkins, Jay Bentley, and Ray Rice, Pacific Southwest Forest and Range Experiment Station, Misc. Paper No. 56, 12 pp., 1961.
 "Erosion From Mountain Side Slopes Following Fire in Southern California," by Jay S. Krammes, Pacific Southwest Forest and Range Experiment Station, Res. Note No. 171, 8 pp., 1960.
 "Saving Water Through Chemical Brush Control," by Robert A. Merriam, Jour. Soil and Water Conserv., 16(2): 84-85, 1961.
 "The San Dimas Large Lysimeters," by James H. Patric, Jour. Soil and Water Conserv., 16(1): 13-17, 1961.
 "Water Use by Brush, Grass and Grass-Forb Vegetation," by P.B. Rowe and L.F. Reimann, Jour. of Forestry, 59(3): 175-181, 1961.
 "An IBM 704 Computer Program for Polynomial Computed Points," by Sharon B. Roof and Clyde Shumway, Pacific Southwest Forest and Range Experiment Station Res. Note No. 183, 2 pp., 1961.

(2415) WATERSHED MANAGEMENT RESEARCH, NORTHERN CALIFORNIA.

- (b) Laboratory project.
 (c) Dr. R. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
 (d) Experimental field investigations basic and applied research.
 (e) The aim is to develop a hydrologic base for land management decisions. The hydrologic effects of wildfires, of attempts at conversion of brushlands to grass, and of logging and other land uses are to be evaluated. Present studies emphasize development of methods of management of high elevation

snowpacks for maximum control and yield of water.

Major work center is in Berkeley with 18 studies being conducted throughout northern California in the headwaters of the Kings, American, Yuba, Truckee, and Feather rivers. At the Teakettle watersheds in the headwaters of the Kings River Basin, 5 small watersheds are under calibration for evaluation of streamflow and sedimentation. In the Onion Creek watersheds in the headwaters of the American River Basin, 5 streams are being gaged and sediment measured. Snow accumulation and soil moisture are being measured in logged and unlogged forest and in brush areas, at both Onion Creek and Castle Creek. Castle Creek in the Yuba River Basin is being gaged, suspended sediment measured, and basic snow physics studies are under way. Daily meteorological measurements are being taken at 3 stations, and radiation and snow physics at the headquarters station. At Sagehen Creek in the Truckee River Basin, sediment and streamflow and their effects on fishlife are being studied in cooperation with the Department of Zoology, University of California. Also the effects of conversion of brushfields to forest are being studied.

At Swain Mountain Experimental Forest in the Feather River Basin, snow and soil moisture are being measured where forests were cut in strips and blocks and where logging slash was treated and untreated. In all, snow accumulation is being measured at 91 special snow courses, soil moisture at some 300 points.

- (g) Present forest and other land conditions of the major river basins reaching up into California's snow zone, will limit the possibilities of management of those watersheds for improved water yield. How much of the snow zone area is subject to management for increased water yield? An inventory of the forest and brush cover in the Sierra west-side above 5,000 feet made by Richards gives some indication. Amounts of moderate and dense forest cover and brushlands are summarized by major river basins, arranged in order from north to south, see table 1:

Table 1

Drainage Basins	Forested	Large Brushfields
	Percent	Percent
Feather River	24	27
Yuba River	22	39
American River	21	24
Mokelumne River	23	17
Stanislaus River	26	17
Tuolumne River	16	16
Merced River	23	16
San Joaquin River	28	15
Kings River	26	12
Kern River	39	9
Kaweah & Tule River	45	13
Average	25	17

We see that 42 percent of the high elevation Sierra Nevada has vegetative cover which might be subjected to management for improved water yield. Brushlands subject to management are greatest in the northern river basins, forests in the southern basins. Benefits in terms of increased water yield may result from harvesting of forest timber crops; water benefits in brushland conversions may help pay for such conversion. In the headwaters of the American River streamflow and sedimentation have been measured in five small watersheds for 3 years. Annual discharges in 1960 averaged some 42% higher than in 1959. Annual discharges for 1960, together with the maximum discharge of the year, are given in table 2:

Table 2

Watershed	Drainage Area sq. mi.	Maximum Yearly Discharge cfs/sq.mi.	Annual Flow 1960 inches
Onion Cr. No. 1	0.19	17	20.9
No. 2	0.48	27	25.4
No. 3	0.65	16	23.1
No. 5	0.39	43	27.6
No. 7	0.80	25	21.8

Daily discharge records for the 5 watersheds for the water year 1959 are published in USGS Water Supply paper No. 1635. Reservoir sedimentation in the moderately low runoff year of 1960 ranged from 0.010 to 0.027 AF/sq. mi.

Streamflow and sedimentation were measured in another set of 5 small watersheds in the southern Sierra Nevada. Peak discharges between the watersheds were quite similar to those in previous years. Maximum discharges and annual flow for 1960 are given in table 3:

Table 3

Watershed	Drainage Area sq. mi.	Maximum Yearly Discharge cfs/sq.mi.	Annual Flow 1960 inches
Teakettle No. 1	0.77	9	8.1
No. 2A	0.27	4	6.0
No. 2	0.85	3	5.9
No. 3	0.86	4	7.6
No. 7	0.09	6	8.9

Sediment deposition for the watersheds was very low in 1960, ranging from zero to 0.07 AF/sq. mi.

Snow density profiles were measured using the radioactive gamma and neutron probes in the Sierra Nevada. First indications are highly encouraging in the range of snow density of 17 to 45 percent. In this range, the gamma probe as compared with standard SIPRE tubes, shows approximate linear relationship, with a standard error of estimate of about 5 percent density. Use of the neutron probe shows much greater dispersion than the gamma probe results, but neutron tube results may be useful in appraising high density snow, where gamma probe results are not linear.

Radiation measurements in forest stands have been made possible by a newly designed "dirt cheap" radiometer, designed and furnished us by the Rocky Mountain Forest and Range Experiment Station. These radiometers were calibrated against the Beckman-Whitley net allwave and incoming allwave radiometers. For one-half hour readings, the correspondence is very good, linear with nearly zero intercept through the range of -0.05 to 0.40 langley per minute. Standard error of estimate is approximately 0.03 langley per minute for 30-minute readings. The reliability of precipitation measurements, ranging from hourly measurements in intensity gages to season-long storage and high elevation storage type gages, was explored. Court found as much as 30 percent variation in hourly precipitation in gages located only a few feet apart. In another study snow storage-gage measurements were compared with snow-course measurements and with aerial determinations of snow cover in the Kings River basin. Indications were that snow storage-gage measurements frequently give rather poor measure of the total precipitation in the area and that one could not infer the volume of water stored as snow from snow-course measurements alone. Summer soil moisture losses and snow accumulation and melt were measured in a logged

area, an unlogged area, in a power line clearing, and in a brushfield. The logging was a commercial diameter-limit cut, in which all trees greater than 18 inches in diameter were removed. Comparisons of snow accumulation and melt of the cut and uncut old-growth red fir forest at an elevation of 7,000 feet for different dates from December, 1960 to May, 1961 are shown in table 4:

Table 4

Treatment	Water Equivalent - Inches				
	Dec.22	Jan.12	Feb.28	Apr.5	May 2
Forest Cut	12.3	11.8	17.2	20.7	12.3
Forest uncut	8.8	8.4	9.8	12.9	9.0
Difference	3.5	3.4	7.4	7.8	3.3

Again in 1961 as in 1958 through 1960 there was more water left at the time of maximum pack in the cut forest than in the uncut. This year the difference was about 8 inches more; in other years the differences have ranged from 7 to 10 inches. Snow melt in the cut area was again faster so there were only three inches more water in the cut forest later in the spring. If the more rapid melt in the cut forest continued, the last snow would be found in the uncut forest. To serve as a contrast to the commercial diameter-limit cutting method, two transects were established across a power line clearing. The clearing runs in an east-west direction on a 20 percent north slope, at an elevation of 6,850 feet. The clearing width was 200 feet, or about 2 times the height of the adjacent old-growth red fir trees. Four conditions are compared: 1) a 125-foot wide strip of the forest margin to the south, 2) a part of the strip 100 feet wide, which had been cleared some time ago and now has a young stand of pine reproduction approximately 8 feet tall (35 years old), 3) a contiguous strip cleared 20 years ago which now has no trees, and 4) the old-growth forest on the north margin of the power line clearing. Mean snow water content at four times during the winter of 1960 (average for ten points each), is given in table 5:

Table 5

Condition	Snow Water - Inches				
	Jan.20	Mar.13	Apr.11	May 2	June 7
South, Forest	8.0	11.4	11.9	9.5	1.0
South Cut with Saplings	14.6	23.3	25.4	21.2	0
North, Clear Cut	14.0	21.5	19.0	16.0	0
North, Forest	6.2	9.6	8.8	6.7	0

The windward (south) margin of the forest had more snow than the opposite side, 3 inches more at maximum pack. Snow in the cut strip was about 12 inches greater than in the average of the forest adjacent, with the most snow being at the south margin of the strip. The slowest snowmelt was in the forest, and the last water was left in the forest near the south margin. Snow accumulation and melt during the winter of 1961 at the Onion Creek brush plots (elevation 6,800 feet) are summarized in table 6:

Table 6

Site	Water Equivalent - Inches		
	Dec.13	Jan.9	Feb.28
Block C, level ridge	10.4	10.0	12.2
Block D, 24% W slope	9.6	6.8	4.3
Block E, 21% SE slope	8.8	9.0	7.4
Average	9.6	8.6	8.0

Site	Water Equivalent - Inches		
	Mar. 20	Apr. 9	May 2
Block C, level ridge	13.6	8.8	2.4
Block D, 24% W slope	8.8	1.7	0
Block E, 21% SE slope	12.6	6.6	0
Average	11.7	5.7	0.8

Again this year the west exposure had considerably less snow than either the level area or the southeast exposure. Mid-winter melt occurred on the sloping courses. Spring melt was slowest on the level area, next on the southeast slope, and greatest on the west slope. Summer water losses in the commercial diameter-limit cutting (cut in 1957) were again compared with those in the uncut forest. Three-year summary of soil-moisture deficit and summer precipitation is:

	1958	1959	1960
	-- inches --		
July-October Precipitation(P)	6.0	3.5	1.6
October soil-moisture deficit (SM)--Unlogged	8.4	9.0	10.0
October soil-moisture deficit (SM)--Logged	7.5	8.2	9.4
Difference	0.9	0.8	0.6

Summer precipitation was about 40 percent effective in reducing soil-moisture deficit. For the unlogged forest the relation is:

$SM = 10.7/P^{0.137}$ (for 1.5 P 6.1). The difference in losses between logged and unlogged sites may be partly caused by precipitation differences and partly by root regrowth from 1958 to 1960; the two effects are compounded in these data.

A study plan was completed outlining the procedure for evaluating the amounts and timing of delivery of water from various topographic and forest conditions of wild-land watersheds in the northern part of the state. An exploratory study was made by Court, seeking methods of expressing streamflow and its variability. Court studied the relationship of the first and third quartiles of the annual flow the maximum flow dates in different years and watersheds. He called the number of days between the first and third quartile flow dates, the half-flow interval. The maximum flow date showed much more variability than the half-flow dates in four southern Sierra watersheds, and the half-flow interval was surprisingly similar for the various basins, being in the neighborhood of 40 days. Court says, "This indicates that as much water comes down these streams during a peak 40-day period as flows during the entire rest of the year." For the years with the greater streamflow, more streamflow comes later; for example, years when the streamflow was 100 percent greater than average, the half-flow date was delayed 17 days. Court concludes: "Whether the half-flow date is the best or even a good criteria for use in analysis of streamflow timing can be determined only by further investigation."

Two more years of snow measurements from 90 to 104 sites have been summarized to give the maximum snowpack water for each year for different slopes, forest openings of different sizes, and forests of different densities. The data have been adjusted to give estimated snow water near the maximum pack--April 1, 1960 and near April 1, 1961. The adjustment was accomplished by using a degree-day factor for each course or part of course and extrapolating backward to the day of maximum pack.

For both 1960 and 1961 the data were adjusted to a common elevation, 7,000 feet, by adding 1.2 inches for each 100 feet that the course was higher than 7,000 feet in elevation. The elevation of each course is given so these adjustments may be eliminated as needed in some analyses. With these adjustments, we feel that the effects of slope, aspect, and forest conditions on snowpack can be directly compared in table 7:

Table 7

Topography	Snow Water, April 1, 1960		
	In Opening	In Surrounding Forest	Average
	-- INCHES --		
North Slopes	36.9	27.8	32.4
West Slopes	32.1	29.2	30.6
Level	32.6	28.3	30.4
East Slopes	32.2	24.7	28.4
South Slopes	26.3	22.0	24.2

Openings had from 3 to 9 inches more water than the surrounding forest at the time of maximum pack. In 1960 the difference between north and south slopes was 8.2 inches as compared to 9.2 inches in 1958 and 1959. The trapping of cold air at the downhill margin of forest openings again appears to be an important mechanism in delaying winter snowmelt. The downhill sides of forest openings always contain more snow than the uphill side of the same opening. West made a detailed study of four courses selected because of the expected imperviousness of the lower opening boundary. The opening sizes were all small, from one-half to one times the tree heights across. For three years, 1958, 1959, and 1960 at the time of maximum snowpack accumulation, the lower part of the forest opening had more snow than the upper part of the same opening: North slopes from 3.0 to 4.0 inches more, south slopes from 3.4 to 9.1 inches more, east slopes from 4.8 to 7.0 more, and west slopes from 9.0 to 13.1 more. West examined other possible mechanisms than cold air drainages in effecting these differences, but concluded, "Cold air drainage...seems to have the most effect on snowpack, causing the accumulation to be greatest in the downslope segments of forest openings." A simple test, using snow courses on slopes of east and west aspect, showed greater "cold air effects" on steeper slopes, those of 30 percent, than on those of 15 percent. To study further the effect of cold air barriers in snow accumulation and melt, we have started a study of barriers using paper dams to trap cold air. Paper dams from 3 to 12 feet high were installed across the lower edge or on contour at intervals within five forest openings. Only part-year records were obtained this first year; the data have not yet been analyzed. Streamflow and suspended sediment were again measured in the Castle Creek watershed, a portion of which was logged in 1958. Analysis of data indicates about 1.75 inches increase in water yield from the entire basin, or the equivalent of about 7.0 inches from the logged area. Suspended sediment again decreased this third (1961) season. Because no high flows occurred in this very low runoff year, no attempt was made to calculate the average sediment production under average streamflow conditions; however, sediment concentration for similar streamflow classes can be compared in table 8:

Table 8

	Suspended Sediment Concentration for Streamflow Discharge Classes	
	15-54 cfs ppm	55-79 cfs ppm
Before logging, 1957-58	5	20
1st year after logging, 1958-59	10	190

	15-54 cfs ppm	55-79 cfs ppm
2nd year after logging, 1959-60	15	90
3rd year after logging, 1960-61	10	45

The rate at which the concentration of sediment is decreasing in the higher discharge classes appears significant; note that the second and third year after logging in each case the sediment concentration in that class was about 1/2 of the previous year's concentration.

An evaluation of summer evapotranspiration in relation to forest sites has been made. In summer the depletion of soil moisture from forest, shrub, and bare sites has been shown to be related to the saturation vapor pressure deficit (VPD) and the day-length (DL). When soil moisture depletion in the years 1958 and 1959 was plotted against the accumulation of this index (VPD x DL), a single rate coefficient was found to fit the exponential curves for both years of the study. It was found that there appeared to be a linear relationship between the rate of evapotranspiration from forest sites and the level of soil moisture. At red fir forest and Lytton soil series sites, summer soil moisture deficits established in the period June to November, 1959, were as follows: 2 inches per foot for the top 5 feet, 1.7 inches per foot for the 6- and 7-foot, and 1.1 inch per foot for the 8- and 9-foot soil depths. By using the soil moisture deficits obtained, the summer rainfall loss, and the distribution of soil depths obtained from some 535 sampling points in the Central Sierra, we may estimate the average soil depths, summer deficits, and total summer losses. Average soil depth was 43 inches. Summer soil moisture deficit at the end of September, 1959, averaged 6.6 inches; October to November, 1959, losses averaged an additional 0.4 inches; and total summer water loss, including 3 inches of summer rainfall, averaged 10.0 inches. These data apply to forest, brush, and herbaceous sites generally, and take no account of the some 27 percent of bare ground and rock in the area.

Snow accumulation and melt data from a strip cut in the forest, under three systems of logging slash disposal, and from adjacent non-cut forest have been summarized. Snow course measurement dates in the years 1958 through 1961 were selected such that the amount of snow in the "control courses" was approximately equal. Snow water in the old-growth red fir forest on both sides of the 5-chain wide strip was compared with the snow in the cut strip (slash had been removed by dozing and burning). Before cutting the strip, the snow in that area was about 1 inch less than in the other part of the forest; after cutting the strip, snow in the cut strip was from 8 to 15 inches greater than the snow in the adjacent forest. For this strip, cut in a southeast-northwest direction, the snow in the southwest margin of the forest was from about 1-1/2 to 6 inches greater than in the northeast margin, (see table 9).

Table 9

Snow Course	Average Snow Water - Inches 2-6-58 4-2-59 3-7-60 3-31-61			
SW Forest Margin (4 points)	14.4	13.4	17.0	14.5
Cut Strip (7 points)	13.9	22.0	24.0	28.6
NW Forest Margin (4 points)	16.0	7.0	15.2	13.0
Control (15 points)	20.0	16.3	20.8	20.3

Other differences in snow accumulation were related to how the slash in the cut openings was treated. At the time of maximum snow-pack in 1960 and 1961, the differences between the different slash treatments ranged from about 1 to 5 inches, the area in which slash had been piled and burned having the most snow. Differences in snow water left late in the spring were as much as 5 inches; again the piled and burned area had the most snow. The data on snow at maximum accumulation and late season snow are given in table 10:

Table 10

Logging Slash Treatment	Average Snow Water Equivalent Inches			
	3-7-60	4-29-60	3-31-61	5-1-61
Piled and burned	24.0	13.2	28.6	21.0
Lopped to 18 inches	-	11.4	25.8	16.2
Left as it fell	19.0	8.5	27.9	-

Examination of the mass of data indicates that the different treatments of slash had their effect only in early winter and in late spring when snowpaks were shallow. For example, in 1961, March accumulation was identical in all three treatments--8.3 inches of water. However, the large differences in 1960 developed early in the year apparently because of the low snowfall as compared with 1961--about 3 to 4 inches in the opening on January 5, 1960, as contrasted with 10 to 15 inches in the opening on January 4, 1961. We would conclude that during those periods when snow cover on the ground is shallow, slash on the ground accelerates melt.

In a study of sediment sources and sedimentation causes in northern California, some quantitative relationships between soil erodibility and soil forming variables have been found. The general model being examined is: sediment production = f (meteorological causes, terrain and land use modifiers, and inherent erodibility of the soil). The specific model of soil erodibility is: soil erodibility = f (geologic rock type, vegetation cover type, elevation, and geographic zone). We used 8 geologic types, 3 vegetation types, 4 elevations, 3 zones and the interactions of geology times zone and geology times vegetation; in all, 67 constants were fitted by regression analysis. Geologic type was significant at the 0.5 percent level, vegetation at the 5 percent, and the geology times zone and geology times vegetation at the 10 percent level. The relative soil erodibility associated with soils developed on the various geologic rock types is shown below (considering the surface-aggregation ratio (S/A) as the index of erodibility and assigning acid igneous rock an erodibility of 1.00):

Rock Type	Relative Soil Erodibility
Acid Igneous	1.00
Alluvium	0.95
Schist	0.83
Soft Sediments	0.57
Hard Sediments	0.50
Basic Igneous	0.43
Other Metamorphics	0.40

These relative erodibilities agree quite closely with those found for the same rock types in western Oregon. Regarding surface-aggregation ratio, will improvement in the estimation of the ratio be obtained by analysis of chemical characteristics of the soil colloids? In a study by Wallis and Stevan the amount of calcium and magnesium absorbed on the clays was found related to the surface-aggregation ratio. Would a combination of chemical characteristics and soil

forming factors give even better prediction of erodibility? For a selected sample of 20 soils we tested the combination: (1) surface-aggregation ratio (s/a) as computed from the soil forming factors, and (2) the calcium plus magnesium, expressed as milliequivalents per hundred grams of soil. This prediction equation was obtained:

$$S/A = 156.4 + 1.06 (s/a) - 17.11 \times (Ca + Mg) + 0.4 \times (Ca + Mg)^2.$$

The t's were all significant. The addition of the soil forming factors of geology, vegetation type, elevation, and zone improved the explained variance obtained by Wallis and Stevan by 30 percent (from 0.48 to 0.63). The time since logging is being studied as a factor in determining the summer water losses. Seven new sites have been selected which range in time since logging from 1 to 12 years. Soil moisture samples have been taken at points starting within the unlogged area and transecting the logged area. The summer water losses associated with the remaining trees extended only about 1/8 the tree height into the cut area the first year after the cut. The roots of the trees at the margin of the opening gradually reached into the opening and their effect eventually reached a distance equal to 1/4 to 1/2 the height of the trees.

- (h) "Proposed Program for Watershed Management Research in the Lower Conifer Zone of California," by H.W. Anderson, Pacific Southwest Forest and Range Experiment Station Tech. Paper No. 46, 21 pp., 1960.
- "Prospects for Affecting the Quantity and Timing of Water Yield Through Snowpack Management in California," by H.W. Anderson, 28th Ann. Proc. Western Snow Conference, pp. 44-50, 1960.
- "A Hemispherical Forest Photocanopymeter," by Frank G. Clark, Jour. of Forestry, 59(2): 103-105, 1961.
- "Reliability of Hourly Precipitation Data," by Arnold Court, Jour. Geophys. Res., 65(12): 4017-4024, 1960.
- "Floating Trashbar for V-notch Weirs," by Clark H. Gleason, Jour. Soil and Water Conserv., 16(1): 35-36, 1961.
- "Watershed Management...an Annotated Bibliography of Erosion, Streamflow, and Water Yield Publications from the Pacific Southwest Forest and Range Experiment Station... Supplement No. 1," by Clark H. Gleason, Pacific Southwest Forest and Range Experiment Station Tech. Paper No. 53, 15 pp., 1960.
- "Folklore About Snowfall Interception," by David H. Miller, Pacific Southwest Forest and Range Experiment Station, 5 pp., proc., April 1961.
- "Terrain Features of Drainage Basins of Sierra Nevada West-Side Snow Zone," by Lucille G. Richards, Pacific Forest and Range Experiment Station Tech. Paper No. 58, 11 pp., May 1961.
- "Erodibility of Some California Wildland Soils Related to Their Metallic Cation Exchange Capacity," by James R. Wallis, Jour. Geophys. Res. 66(4): 1225-1230, 1961.
- "Cold Air Drainage in Forest Openings," by Allan J. West, Pacific Southwest Forest and Range Experiment Station Res. Note No. 180, 5 pp., April 1961.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Rocky Mountain Forest and Range Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Raymond Price, Director, Rocky Mountain Forest and Range Experiment Station, Room 221 Forestry Building, Fort Collins, Colorado.

- (377) WATERSHED MANAGEMENT RESEARCH, FRASER
HYDROLOGIC LABORATORY.

- (b) Laboratory project.
(d) Field investigations; applied research.
(e) To determine influence of lodgepole pine and spruce-fir forests and of the management of these forests for wood products on factors associated with the yield of water, largely from stored snow. The purpose is to solve problems in the management of forested watersheds of the high altitude zone of the Rocky Mountains for maximum yields of usable water.
(g) The estimated increase in water yield from the Fool Creek watershed due to timber harvesting has been:

Year	Acre-feet
1956	254
1957	200
1958	125
1959	186
1960	226
1961	120

- (h) "Management of Alpine and Subalpine Mountainous Area for Water Yield," by L.D. Love, New Mexico Annual Water Conference. Proc. 5: 39-44, illus. (Processed).

(657) WATERSHED MANAGEMENT RESEARCH, TEMPE, ARIZONA.

- (b) Laboratory project.
(d) Experimental; basic and applied research.
(e) To study the disposition of rainfall as influenced by watershed vegetation; to determine the influence of various types of forest and grassland vegetation as well as vegetation modified by cultural treatment such as grazing and timber harvest, on streamflow, water use, water loss, and erosion and sediment yield; and to determine for phreatophytic vegetation (water-loving plants) the amount of water used, methods for reducing water use by phreatophytes or for replacing them with more useful plants; and for mixed conifer and chaparral types of vegetation to determine the hydrologic characteristics of natural watersheds and the effect of cover modification upon water yields, soil stability and other resource values. At Sierra Ancha Experimental Watersheds in central Arizona, rainfall, runoff, and erosion are measured on three watersheds in the pine-fir vegetation type at high elevation, on two watersheds in the ponderosa-chaparral type, and from four watersheds in the grassland-chaparral type at intermediate elevations, and on nine small watersheds in the semidesert-chaparral type at low elevations. Water use by different types of plants in various soils is studied on eleven large lysimeters. Three watersheds have also been established in the pure ponderosa pine type and two in the mixed conifer type to test the effects of logging practices upon water yield and soil stability. Gaging stations for four watersheds in the pure chaparral type are also available to evaluate watershed-game interrelations. One cluster of two watersheds and another cluster of three watersheds are available for testing the effect of manipulating chaparral cover. Supplemental studies are determining the proper use of chemicals, fire, and mechanical treatment for manipulating shrubs in the type. Interception, moisture use, and factors affecting water yield are being tested in Utah and alligator juniper forests on the Beaver Creek Project, south of Flagstaff, Arizona.
- Ecology of Tamarix pentandra and other phreatophytes is under investigation. Germination, seedling survival, and rate of spread studies were continued. A field apparatus employing the infrared analyzer for detecting moisture has been used for detailed measurements of evapotranspiration of phreatophytes.

- (g) In pine-fir forests streamflow peaks tended to occur when south slopes were almost bare and when north slopes were about half covered with snow. Timing of peak discharge was related to elevations. In dominately grassland areas, surface runoff lasted less than 2 months although relatively high peak discharges occurred on these areas. On grass, aspen, and mixed conifer plots, soil moisture measurement from 1/2 to 9 feet deep for April to September indicated water use as follows: 12.5 inches for grass, 20.6 inches for aspen, and 15.5 inches for mixed conifer. Summer precipitation was 5.9 inches. The presence of free water under grass and aspen probably indicates water loss from this water moving out into an underground source as well as use by plants. On dense, mixed oak chaparral watersheds, 23 months, after wildfire, annual and perennial herbs were distributed with about equal frequency. No difference in percent of plots dominated by all perennials vs. all annuals was associated with exposure. Cover change on a chaparral watershed is reflected in duration and volume of streamflow. Precipitation and streamflow on watershed D at 3-Bar, Arizona, was as follows:

	<u>Runoff</u>	<u>Precipitation</u>
Water year - 1957	2.34	24.71
Water year - 1960*	12.85	31.78

* First full year after cover change by wildfire.

An instrument for determining relative sap velocity of trees in their natural environment is being field-tested in the pinyon-juniper type. The instrument has performed well and has been used to investigate diurnal trends, variability within and between trees, and responses to environmental factors.

Drying of tamarisk stem cuttings reduced its sprouting ability. Loss of sprouting ability after drying is greatest when the stems have the most moisture. In June, stems have reached their maximum moisture and are most susceptible to kill by drying. Dry stems collected in November and December retain much of their ability to sprout even after losing 30 percent of the stem moisture.

- (h) "Salt Secretion by Tamaris Pentandra Poll," by John P. Decker, Forest Science 7: 214-217, illus.
 "Nitrogen Aids Plant Growth on Arizona Soils Derived from Granite and Diabase," by Howard C. Gary and Lowell R. Rich, Research Note 57, 2 pp., (Processed).
 "Ecology of Saltcedar," in Watershed and Related Management Problems, by J. S. Horton, Arizona Water Res. Comm. and Arizona State Land Dept. Proc. 4: 19-21, 1960, illus., (Processed).
 "Vegetation Management for Water Yield in the Southwest," by Hudson G. Reynolds, New Mexico Annual Water Conference, Proc. 5: 21-33, illus., (Processed).
 "Some Hydrologic Influences of Cabling Juniper," by C. M. Skau, Research Note 62, 2 pp., (Processed).

(1969) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

- (b) Laboratory project. Some work in cooperation with Bureau of Land Management and Geological Survey.
 (d) Applied research.
 (e) Evaluation of range-watershed conditions on small watersheds in the San Luis drainage of the Rio Puerco. Three contiguous watersheds, ranging from 338 to 555 acres located about 8 miles north of the San Luis community and west of the Rio Puerco main channel provide the study area. Water and sediment inflow are measured in small reservoirs formed by earthen dams. Precipitation rates and

amounts of vegetation changes are periodically measured over the watersheds. Six years of data have been collected under cattle grazing during a 5-1/2 month overwinter period (November 1 to April 30). Soil elevation measurements have been obtained on the three watersheds for purposes of determining soil losses from the alluvial soils. Rising stage sediment samplers have been installed on the three watersheds. Evaluation of soil pitting (Calkins pitter) on surface runoff, erosion and vegetation. Surface runoff plots (20), 10' by 30', are installed on 3 slope aspects, representing different soil conditions, in the Rio Jemez drainage. Precipitation, runoff, sediment and changes in vegetation are measured. Evaluation of soil ripping (Jayhawker) on surface runoff erosion and vegetation. Surface runoff plots (62), 10' by 30', are installed on a north and south aspect and upper and lower slopes representing different soil conditions in the Rio Jemez drainage. Seeding grass (alkali sacaton) and browse (chamiza) and protection from livestock and rabbits is also evaluated. Precipitation, runoff, sediment, and changes in vegetation are measured.

To obtain: 1) Preliminary information on streamflow characteristics for correlation with snowpack ablation and summer rainfall; 2) information on relative water yields from several vegetation zones in high altitude watersheds in New Mexico; 3) information on the amount and occurrence of precipitation received in study areas; and 4) information on the range of flows to be expected so that suitable equipment can be designed and installed for more permanent stream gaging.

- (g) Grazing use by cattle has averaged 57% on the key species alkali sacaton and only 40% on the less preferred galleta species. Fencing and variation in class of cattle have had a pronounced effect on the grazing pattern. Reduction in surface runoff caused by pitting during the first rainy season averaged 10% and 26% for the south and north exposures, respectively. Soil ripping with the Jayhawker resulted in about 98% reduction in surface runoff during the first rainy season. Portable waterstage recorders and crest gages have been placed on selected streams at culvert locations. Precipitation storage gages are located on the selected experimental watersheds in the Sangre de Cristo range in New Mexico.
 (h) "The Rio Puerco--Past, Present, and Future," by E. J. Dortignac, New Mexico Water Conference. Proc. 5: 45-51, illus., (Processed).

(2658) WATERSHED MANAGEMENT RESEARCH, RAPID CITY, SOUTH DAKOTA.

- (b) Laboratory project.
 (d) Experimental; basic and applied research.
 (e) Study of basic soil-water relationships under ponderosa pine to determine how thinning of dense stands influences water use. Runoff and soil erosion from plots on the September 1959 Deadwood Burn in relation to development and re-establishment of seeded and native plant cover. Development of a diversion type sampler for measurement of sediment and runoff in small streams. Measurement of runoff from plots on grazed and protected Kentucky bluegrass range to obtain information that can be used as a management tool.
 (g) In each of two dry years following a year of above average precipitation (average annual precipitation is approximately 21 inches) thinned ponderosa pine of post-pole size used more moisture than unthinned pine. In both dry years, both the thinned and unthinned pine used all incoming moisture. The thinned

pine also used some holdover soil moisture from the wet year while there was no holdover moisture available under unthinned pine. Difference in moisture use during the second of the two dry years was less than in the first due to partial depletion of stored soil moisture under the thinned pine. Plots on the 1959 Deadwood Burn have produced more runoff from snowmelt on frozen ground than summer storm runoff. Summer storm runoff has been universally proportional to plant cover. Snowmelt runoff has depended primarily on amount of snow accumulation; plant cover apparently having had little effect on amount of runoff.

- (g) "Annual Report for 1961, Rocky Mountain Forest and Range Experiment Station," U.S. Forest Service, Fort Collins, Colo.

(2913) BEAVER CREEK WATERSHED PROJECT.

- (b) Laboratory project, cooperative with Coconino National Forest, Flagstaff, Arizona.
- (d) Field investigation; basic research.
- (e) Calibration of 12 small watersheds, 6 in ponderosa pine type, 3 in alligator juniper type, and 3 in Utah juniper type. A newly designed modified trapezoidal Venturi flume is being used to measure discharge from these steep ephemeral streams. Precipitation measurements are being taken. Also, calibration of 2 large watersheds in the ponderosa pine type. A newly designed stream gage is being used on these watersheds. It consists of a 15 foot wide concrete slab with a 6 inch lip on the downstream edge. The slab is used for metering and the lip creates a shallow impoundment which permits metering low flows. The entire structure has the shape of a shallow V with 1:5 slope at the center and 1:10 slope on the sides.
- (g) Based on 3 years' data: Streamflow from the Utah juniper type (5,500' elev.) averaged .70 area inch; in the alligator juniper type (6,000' elev.) streamflow averaged 3.00 area inches; in the ponderosa pine type (7,200' elev.) streamflow averaged 4.00 area inches.

(3569) WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING.

- (b) Laboratory project.
- (d) Field investigation; applied research.
- (e) The objectives of the study are to determine the effects of big sagebrush on total runoff from snowmelt, snow accumulation and storage pattern. Three high elevation sagebrush watersheds, 60 to 106 acres, in western Wyoming provide the study area. V-notch weirs gage the runoff, and suspended sediment samples are taken periodically. Snowpack is sampled along permanent transects and at random points. Precipitation is sampled by a network of recording and non-recording gages.
- Study to evaluate the comparative efficiencies, in terms of water stored in accumulated snow, of tandem 4-foot slatted snow-fences erected at three different spacing intervals on open windswept slopes in southeast Wyoming. The objective of this study is to determine the soil moisture withdrawal pattern under natural stands of big sagebrush, and the effect of sagebrush eradication on moisture withdrawal. Four 0.1 acre plots on an east and a west exposure have been established within high elevation sagebrush type in western Wyoming. Sagebrush on two of the plots on each exposure will be eradicated by spraying. Gravimetric soil samples are taken periodically to trace the soil moisture withdrawal under each condition.
- (g) Total runoff from the experimental drainages declined from 1.33 inches in 1960 to 0.97 inches during 1961. Conversely, maximum instantaneous peak flows increased from 1.9 c.f.s. to 2.5 c.f.s., accompanied by an increase in maximum suspended sediment load of from 53 ppm in 1960 to 476 ppm in 1961.

During the winter of 1960-61, fences arranged in tandem at 325 feet intervals accumulated 110 cubic feet of water held as snow per lineal foot of fence. Fences arranged at spacings of 175 and 250 feet accumulated 75-78 percent of this amount. Studies during the winter of 1961-62 will be limited to larger scale field trials of 325 foot spacing.

During 1960 natural stands of big sagebrush withdrew 8.49 inches of soil moisture on the east exposure and 6.88 inches on the west exposure. During 1961, on east exposures, sprayed stands withdrew 9.32 inches while untreated stands withdrew 7.71 inches. On west exposures, sprayed and unsprayed stands withdrew similar amounts.

- (h) "Some Influence of Timber Cutting on Snow Accumulation in the Colorado Front Range," by Herbert W. Berndt, Research Note 58, 3 pp., illus., (Processed).

(3895) WATERSHED MANAGEMENT RESEARCH, ALPINE HYDROLOGIC LABORATORY.

- (b) Laboratory project.
- (d) Field investigations; basic research.
- (e) The purpose is: 1) To correlate snowdrift intensity with meteorological and terrain features; 2) to measure the amount and vertical distribution of snow carried by the wind in an area of moderately rough terrain; 3) To determine important features associated with the deposition of snow; 4) to determine the effect of slat and wire fencing on the accumulation of snow in selected natural catchments in the alpine portion of Loveland Basin, Colorado, and to test the relative effectiveness of this type of fence at two locations in the same general area; and 5) to test several types of wind barriers in alpine conditions.
- (g) One year's data have been taken on the effect of slat and wire snowfencing on the accumulation of snow in selected natural alpine catchments. Catchments that were alternately fenced and unfenced at intervals during the winter, showed an increase in snow accumulation. Other catchments that had 8-foot tall fences on thin upwind edge for the entire winter season gave mixed results. Two of these showed small gains due to the fences and one showed a definite decrease in snow accumulation as the result of the fence. Positive fence effect was concentrated in an area 8-11 ft behind the fence (when h = height of fence). Beyond this distance snow accumulation was less than normal.

(3896) WATERSHED MANAGEMENT RESEARCH, FORT COLLINS, COLORADO.

- (b) Laboratory project.
- (d) Field investigations; applied research.
- (e) Research to find the most suitable plants for establishment on difficult and badly eroding sites, the best methods of establishing them on various sites, and the influences of mechanical watershed rehabilitation measures on the micro-climate and other site factors in the southern Rocky Mountains.
- To determine the effect of range conditions and related factors on sediment production and runoff on three mountain grassland watersheds in western Colorado. Range condition is being measured by means of 20 or more 3-step transects on each watershed. Ninety degree V-notch weirs are used to gage the watersheds which vary in size from 86 to 272 acres. Water samples are taken several times daily during snowmelt and periods of storm runoff for determination of suspended sediment; bedload is measured in the weir ponds.
- (g) The moist and cool 1961 growing season on the Eastern Slope of the Colorado Front Range has made this a favorable year for initial testing of plant species for erosion control.

Species showing the greatest promise for survival, growth, vigor, freedom from insect, disease, rodent and mechanical damage were: *Prunus besseyi*, *Rosa laxa* x *rubifolia*, and *Eleagnus commutata*, *Brassica nigra*, *Vicia villosa*, *Melilotus alba* var. *Evergreen* and *Melilotus officinalis*. Continued measurements are necessary to fully evaluate these species under different growing conditions.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Southeastern Forest Experiment Station.

(380) WATER RESOURCE AND WATERSHED MANAGEMENT RESEARCH.

- (b) Laboratory project. For general public use and information.
- (c) Mr. J. F. Pechanec, Director, Southeastern Forest Experiment Station, U.S. Forest Service, P.O. Box 2570, Asheville, N.C.
- (d) General investigations of forest influences in the southeastern United States, with primary emphasis on fundamental hydrologic research on watershed processes and related application in watershed management.
- (e) Basic research into forest hydrologic processes from the precipitation of water over an area until it leaves the watershed as streamflow or evapotranspiration. Demonstrations of several cover types and land management practices and their effect upon water yield, quality and flow characteristics. Development of watershed management methods pertinent to the region and cooperative trials and demonstrations of these methods. Most of the experimental and hydrologic data are collected on the 5600-acre Coweeta Hydrologic Laboratory, located in the zone of maximum precipitation for the eastern United States (Nantahala Range of the southern Appalachians). Nineteen individual and two multiple watersheds are currently active and provide the locale for the experimental program, along with an additional 12 standby watersheds whose streamflow has been gaged for over 25 years. Over 650 cumulative years of streamflow records are available for drainages ranging from 4 acres to 8 square miles. One F-P analog-to-digital water level recorder is in service; all other active weirs are serviced by chart-trace recorders. The Laboratory has 10 recording and 76 non-recording (standard) rain gages, 8 recording hygrothermographs, 12 recording soil or water thermographs, 1 metering anemometer, 2 recording anemometers and wind vanes, atmometers, 1 evaporation pan and 2 recording pyrhemometers. Occasional water samples are collected from selected watersheds for quality analysis on a storm period basis. Soil moisture is measured in the field with tensiometers and 2 neutron scattering devices servicing a network of 61 access tubes. A small laboratory equipped for soil physical analysis and instrument repair is on the area. Data reduction from chart trace to punched card is accomplished locally through an Oscar-K chart reader. Basic research in plant-soil-moisture relations in the Piedmont, supplementing the work at Coweeta, is emphasized at the Union Research Center. Current soil moisture studies include development of field measurement techniques for moisture investigations by the neutron method, comparative water use requirements of cover types, moisture recharge and depletion investigations, and depth of moisture withdrawal by representative cover types. Secondary studies deal with hydrologic properties of forest soils. The center has laboratory facilities for analysis of foliage and physical and chemical properties of soils, a portable neutron scattering device for measuring soil moisture, 4 gaged watersheds, three recording and 7 standard rain gages, one recording ground water well, and a standard

Weather Bureau weather station.

All projects are to be carried to completion through analysis of data, preparation of reports and publication of technical articles. Research studies (Coweeta and Union) include: 1) Evapotranspiration from forest land, hydrologic effects of reducing basal area. 2) evapotranspiration and water yield from different types of forest cover; 3) study of the soil-water balance as related to recharge, drainage and evapotranspiration; 4) studies of source, volume and timing of stormflow from small watersheds; 5) studies of energy balance, precipitation and evapotranspiration on slopes and how modified by cover and physiography; 6) recharge, drainage, storage, and depletion of soil moisture in relation to vegetative cover and other environmental factors; 7) soil moisture depletion by drainage and transpiration from plots of forest soil covered with plastic film; 8) internal water balance of forest trees under natural and induced drought conditions; and 9) relation of the amount of forest litter on the ground to interception of rainfall.

- (g) Early demonstrations of good and poor watershed management practices and necessary rehabilitation methods have been of great educational value to the public and have helped document recommendations for proper land practices on public and private lands. Removal of vegetation from selected watersheds by several different cutting patterns produced increased annual water yields in the order of 3 to 16 inches without detectable changes in the proportion of stormflow or in soil stability. Currently established type-conversions from existing hardwood cover to white pine and to grass are to demonstrate differential water use, if any, by varying cover types. Several studies of soil moisture storage and movement are in progress. Field and model studies designed to determine the dynamics of moisture storage on steep slopes suggest that much of the base flow in mountain streams is from soil moisture in the zone of aeration rather than from saturated aquifers. Compilation of data from more than 14,000 gravimetric soil samples taken between 1953 and 1958 showed average soil moisture highest in April and lowest in September. The annual curve of monthly streamflow values rose and declined according to that of soil moisture. Trees on plots of deep soil were covered with plastic film during an entire growing season. The trees leafed out, grew, and became dormant as did trees in adjacent uncovered soil. Transpiration loss (about 16") was almost one-half the available water stored in the plot profile. Drainage (about 3") was estimated and separated from transpiration. The internal water balance of several tree species was found to be sensitive to vapor pressure deficit but was much less responsive to the soil moisture variation normally experienced at Coweeta. Studies are underway to relate water yield, stream and soil temperatures to aspect and ultimately to solar radiation. Litter accumulation fluctuates from 4 tons per acre in winter to less than 2 tons during late summer under a typical cover hardwood stand. Maximum interception of rainfall by litter was 210% by weight, a moisture content usually reduced by evaporation within 7 days to an average low of 60% by weight.
- (h) "Mountain Topography and Solar Energy available for Evapotranspiration," by L. W. Swift, Jr. and C. H. M. vanBavel, *Journal of Geophysical Research* 66(8): 2565, 1961.
- "Soil Moisture as a Source of Base Flow From Steep Mountain Watersheds," by John D. Hewlett, Station Paper No. 132, Southeastern Forest Experiment Station, Asheville, N.C. 1961.
- "Response of Fescue to Natural Moisture Gradient on an Artificial Slope," by J. D.

Hewlett, Research Note No. 152, Southeastern Forest Experiment Station, Asheville, N.C. 1961.

"Increases in Water Yield Resulting From Several Types of Forest Cutting," by J. D. Hewlett and A. R. Hibbert, Bulletin of the International Association of Scientific Hydrology 4(3): 5-17, 1961.

"A Method for Calculating Error of Soil Moisture Volumes in Gravimetric Sampling," by John D. Hewlett and James E. Douglass, Forest Science 7(3): 265-272, 1961.

"Processing Streamflow Records for Machine Computation," in-service report of Southeastern Forest Experiment Station, Asheville, N.C. 1961.

"A Study of Commonly Used Hydrologic Concepts and Their Application in Runoff Analysis on Small Mountain Watersheds," by A. R. Hibbert, Master of Science Thesis, Utah State University, Logan, Utah, 1961.

"The Effect of Mountain Topography Under Solar Energy Theoretically Available for Evapotranspiration," by L. W. Swift, Jr., Master of Science Thesis, North Carolina State College, Raleigh, N.C., 1960.

"The Annual Range of Soil Moisture Under High Rainfall in the Southern Appalachians," by J. D. Helvey and J. D. Hewlett, submitted to Journal of Forestry.

"Instrumental and Soil Moisture Variance Using the Neutron Scattering Method," by J. L. Clutter, James Douglass, and J. D. Hewlett. To be submitted to Soil Science.

"Fluctuations of an Artificial Ground Water Table Related to Temperature and Barometric Pressure Changes," by A. R. Hibbert. To be submitted as a Southeastern Forest Experiment Station Note.

"Water Loss From Plots of Forest Soil Protected From Recharge and Surface Evaporation," by J. H. Patric. To be submitted to Proceedings of the Soil Science Society of America.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE,
Southern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. P. A. Briegleb, Director, Southern Forest Experiment Station, 2026 St. Charles Avenue, New Orleans 13, Louisiana.

(2914) WATERSHED MANAGEMENT RESEARCH, OXFORD RESEARCH CENTER, OXFORD, MISSISSIPPI.

- (b) Laboratory project, in cooperation with Soil Conservation Service, Agricultural Research Service, and University of Mississippi.
- (d) Field investigation of runoff and erosion from small experimental watersheds on forest and potential forest lands; basic and applied research.
- (e) Twelve small natural headwater catchments installed 1957-58 under different forest cover and soil conditions.
- (g) Annual water yield from various soil-cover complexes from 1957 to 1960 appears well correlated with precipitation. Relationship of total runoff to direct surface runoff appears constant for the range of 42 to 62 inches of annual precipitation. Sediment contributions in 1960 varied from 8 pounds per acre from 23-year-old pine plantations to 116 pounds from abandoned fields.
- (h) "Eroded Sites Rebuild Slowly," by D. C. McClurkin, Mississippi Farm Research 24 (3): 5, March 1961.
"Soil Moisture Trends Following Thinning in Shortleaf Pine," by D. C. McClurkin, Soil Sci. Soc. Amer. Proc. 25(2): 135-138, March-April 1961.
"A Hydraulic Soil Sampler," by J. R. Thames, and R. D. McReynolds, Agricultural Engineering 42(8): 431-432, 1961.
"Effect of Cover Types, Soils, and Moisture Storage Capacity on Runoff," by S.J. Ursic,

Proc. SCS-ARS-FS Hydrology Workshop, New Orleans, La, pp. 12.1-12.9, October 24-27, 1960.

"Post-Hole Tree Planting for Stabilizing Gullies," by S. J. Ursic, Journal of Soil and Water Conservation 16(4): 188-189, 1961.
"Soil Moisture-Seedling Growth Relations in Conversion Planting of Oak Ridges to Pine," by H. L. Williston, and D. C. McClurkin, Jour. of Forestry 59: 20-23, January 1961.

(3225) WATERSHED MANAGEMENT RESEARCH, HARRISON RESEARCH CENTER, HARRISON, ARKANSAS.

- (b) Laboratory project.
- (d) Field investigation of hydrologic effects of conversion of mountain hardwood forests to range. Effects of forest management practices on soil moisture regime; applied research.
- (e) Runoff plots installed in 1958 on hardwood areas converted to range and in 1959 on pine areas prescribe-burned for tree seedbed preparation.
- (g) At the end of three growing seasons after hardwoods were killed by aerial spraying, litter-humus weight on plots grazed for the full season decreased from 7800 lbs. per acre to 1200 lbs. Retention and detention storage of the litter-humus decreased correspondingly.
- (h) "Hardwood Removal Lessens Litter-Humus in Ozarks," by J. L. Smith, Annual Report Southern Forest Experiment Station, Southern Forest Research 1: 9-10, November 1960.

(3226) SOIL MOISTURE RESEARCH, VICKSBURG RESEARCH CENTER, VICKSBURG, MISSISSIPPI.

- (b) Waterways Experiment Station, Corps of Engineers, U. S. Army.
- (d) Field and laboratory investigations; basic and applied research.
- (e) Project aims to improve a soil-moisture prediction method.
- (f) Project discontinued February 1961.
- (g) Solar radiation, temperature, and other factors were correlated with moisture loss in the upper 12 inches of soil. Highest correlations of single factors were obtained with soil temperature and evaporation-pan data ($r = 0.79$ each), and with solar radiation ($r = 0.76$).
- (h) "Soil Series can be Grouped for Special Uses," by J. R. Bassett, and L. E. Andrew, Southern Forest Experiment Station, Southern Forestry Notes 130, November 1960.
"Estimating Soil Moisture for Field Studies of Plant Growth," by R. S. Campbell, and Roger W. Rich, Jour. Range Management 14(3): 130-134, 1961.
"Sample Variation in a Falaya Silt Loam," by A. W. Krumbach and J. R. Bassett, Southern Forest Experiment Station Southern Forest Research 1: 11-12, November 1960.
"Correlations Between Soil-Moisture Depletion, Solar Radiation, and Other Environmental Factors," by F. W. Stearns, and C. A. Carlson, Journal of Geophysical Research 65: 3727-3732, illus., November 1960.

U. S. ARMY, CORPS OF ENGINEERS, Beach Erosion Board.

Inquiries concerning the following projects should be addressed to the President, Beach Erosion Board, 5201 Little Falls Road, N.W., Wash. 16, D.C.

(181) EQUILIBRIUM PROFILE OF BEACHES AND STUDY OF MODEL SCALE EFFECTS.

- (b) Laboratory project.
- (d) Experimental.
- (e) Equilibrium beach profiles will be determined experimentally for waves up to 6 feet in height in a prototype tank; the waves will be modeled at a 1 on 10 scale in small laboratory tanks for various median diameter and specific gravity sediments to determine

- scale effect.
- (g) Additional tests were made using crushed coal of average specific gravity 1.5 (modeled by the settling velocity relationship to give corresponding characteristics of material tested in the large tank). Observed material movement and profile changes corresponded basically to the large scale results in the prototype tank, although the coal slope deteriorated somewhat faster. A partial explanation for differences is the wide range of specific gravities of individual coal particles.
- (660) OBSERVED WAVE CHARACTERISTICS.
- (b) Laboratory and field project.
(d) Field investigation; basic research.
(e) To secure a more thorough knowledge of the characteristics of ocean waves, a number of electrical recording wave gages have been installed in coastal waters and these records are analyzed for significant height and period.
- (g) The new type plastic wave gage sections have proven superior to the neoprene coated aluminum channel type and have been installed at all Beach Erosion Board wave gage installations. These new plastic sections are now considered as standard items in all staff type wave gages. Anti-fouling paint has been applied to several of the gages and has proved very effective in reducing the marine growth on the gages, depending upon location. Use of the anti-fouling paint is now considered standard. The wave spectrum analyzer utilizing a revolving tape head is now in the testing stage. Experimental records obtained with a tape recorder at Atlantic City, N.J., are being analyzed for comparison with analysis by hand and by other automatic analyses. The new type staff gage as originally designed by the Beach Erosion Board for use at New Orleans District has proven satisfactory for its intended use. Eight of these gages have been fabricated; 3 for New Orleans District, 1 for use in Hawaii and 4 for Seattle, Washington, District. (This gage is unique in that it is designed to operate in water with salinity changes ranging from fresh water to sea water). A modified type of the new gage for measuring waves with heights up to 45 feet is under construction for installation in Buzzards Bay, Massachusetts (Coast Guard Light Tower).
- (h) "The Beach Erosion Board Wave Spectrum Analyzer and Its Purpose," paper by Joseph M. Caldwell and Leo Williams, Conference on Ocean Wave Spectra, Easton, Maryland, May 1-4, 1961.
"Utilization of Wave Spectra in Shore Processes," paper by Joseph M. Caldwell, Conference on Ocean Wave Spectra, Easton, Maryland, May 1-4, 1961.
- (975) METHODS OF BY-PASSING SAND PAST INLETS.
- (b) Laboratory project.
(d) Field investigation; applied research.
(e) To study methods and requirements for pumping sand past inlets and to determine the applicability of the methods in stabilization of beaches adjacent to inlets. Data are being procured on the effect to the shoreline of a sand by-passing operation at Port Hueneme, California and Lake Worth, Florida, and on the effect to the shoreline of a new harbor being constructed at Ventura, California. This latter project involves an offshore detached breakwater along with entrance jetties to the new harbor. Data at the three locations include periodic hydrographic surveys south and north of the inlet, wave data, sand samples, detailed records of pumping operations, and detailed records of entrance channel maintenance. A general study is being made of the possibility of adapting commercial instruments utilizing a radioactive source to the discharge line to measure quantity of material pumped in by-passing operations.
- (976) ESTABLISHMENT OF CRITERIA FOR CONSTRUCTION OF ARTIFICIAL BEACHES.
- (b) Laboratory project.
(d) Theoretical; applied research.
(e) To develop criteria for construction of beaches by artificial means. The present continuing phase of this general study involves the measurement of a natural beach slope and attempts to determine its response to the forces normally incident upon the shore such as wave height and period, angle of wave approach, tide, and direction and magnitude of littoral current. By statistical methods the relative importance of the forces or combinations of forces may be evaluated.
- (g) Computing machine techniques have been applied to the statistical evaluation of the importance of the forces and of the parameters. Preliminary results indicate that wave height and wave period are more important although, in general, the data used in the analysis were too sparse and too statistically noisy to achieve definitive results.
- (h) "The Analysis of Observational Data from Natural Beaches," by William C. Krumbain, Beach Erosion Board Technical Memorandum No. 130, 60 pages and appendix, December 1961.
- (977) DEVELOPMENT OF WAVE HEIGHT AND WAVE DIRECTION GAGES.
- (b) Laboratory project.
(d) Experimental; development.
(e) To develop wave height and wave direction gages for use in securing accurate records of wave characteristics. (See also Project 660).
(f) Project was inactive during 1960.
(g) Parts for a new type wave direction gage have been placed under procurement. Assembly of the gage has been completed. Laboratory tests of this gage are expected in the next six months.
- (2190) STUDY OF EFFECT OF A GROIN ON THE RATE OF LITTORAL MOVEMENT.
- (b) Laboratory project.
(d) Experimental; basic research.
(e) To study the effect of groins on the rate of littoral drift passing a groin system. Initial tests consist of waves generated at a 30-degree angle to the sand beach. Measurement of material movement is being made at the downbeach end. The tests planned for the immediate future, as have the current season tests, will continue to emphasize the task of establishing sound calibration data relative to littoral transport and wave characteristics. This is now considered a prerequisite to attempting more detailed study and testing on the effects of groins on the rate of littoral drift. These generalized (not to specific model scale) studies are being made in the Shore Processes Test Basin of the Beach Erosion Board. They will include tests on waves up to 1 foot in height and wave periods of 1.25 to 4.00 seconds. They also include tests attempting to determine the effect of wave height and wave period variability on the littoral transport rate.
- (g) The new series of littoral transport tests on an initial 1 on 10 beach slope with beach lengths of 50 feet or less begun in 1959 have been continued through the present 1961 test season. A total of 7 such littoral transport tests have been run this year. The 7 tests cover a wave steepness range of 0.003 H₀/L₀ 0.125. This year's tests have also involved the effect of wave variability on the littoral transport rate.

In these tests waves having constant periods of 2.5, 3.0, 3.75, and 3.0 seconds were generated successively for given constant intervals of time during each test. The length of the constant time intervals was changed for different tests. These time intervals were 5, 1, and 0 minutes respectively for the first, second, and third wave variability tests. The test at zero time interval between wave period changes required that the wave period be changed continuously. This was effected through the use of a motorized eccentric arm applied to the speed control level of the wave generators. The wave period change, though continuous, was not constant but varied sinusoidally. The height of the waves also changed as the wave period was changed. Preliminary results show that generally the littoral transport rate increases as the time between wave period changes decreases, and that the "peak" value of interval time corresponding to the maximum value of the transport rate for the wave and beach conditions used probably lies between 1 and 0 minutes.

Three constant wave period tests starting from an initial 1 on 10 slope have been completed and the results will be compared to similar constant wave condition tests starting from a 1 on 20 initial slope. Work has continued in an attempt to relate measured net quantities of littoral accumulation at several points on the North Atlantic coast to wave energy derived from hindcast wave data.

(2192) REGIONAL STUDIES OF THE SOUTH SHORE OF LONG ISLAND, NEW YORK; ATLANTIC COAST OF NEW JERSEY; AND THE DELAWARE-MARYLAND-VIRGINIA SHORE LINE FROM CAPE HENLOPEN TO CAPE CHARLES.

- (b) Laboratory project.
- (d) Field investigations; basic research.
- (e) To compile all existing data pertinent to shore processes on a regional scale. Reports to consist of three chapters: geomorphology and shoreline histories, littoral forces, and littoral materials. Subject matter to include physiography, geological development of the shore region, sources of littoral material, waves, tides or water level fluctuations, current physical characteristics of the littoral materials, interrelation of sedimentary properties, relation of properties of littoral materials to position in the littoral zone, and changes in shoreline figuration.
- (h) "Geomorphology of the South Shore of Long Island, New York," by Norman E. Taney, Beach Erosion Board Technical Memorandum No. 128, 50 pages and appendices, September 1961.
- "Littoral Materials of the South Shore of Long Island, New York," by Norman E. Taney, Beach Erosion Board Technical Memorandum No. 129, 58 pages and appendices, December 1961.

(2193) SHORE PROTECTION PLANNING AND DESIGN.

- (b) Laboratory project.
- (d) Design.
- (e) The purpose of this project is to supplement and revise the Beach Erosion Board's Technical Report No. 4, "Shore Protection Planning and Design" as new data and techniques are developed for use in the solution of coastal engineering problems.
- (g) This report was reprinted in October 1961. The reprint included revisions of February 1957 and May 1961. It included recent data on forces on piles, rubble breakwater design, sand by-passing plants, and dune stabilization.

(2195) RE-EXAMINATION OF ARTIFICIALLY NOURISHED AND CONSTRUCTED BEACHES.

- (b) Laboratory project.
- (d) Field investigation; applied research.
- (e) To study the behavior of beach fills placed to restore or nourish a beach sector and the effect of the fill on adjacent shores. A selected number of beach fills are being re-examined.
- (g) Survey and sand sample data were taken in 1960 at Prospect Beach, Connecticut. A fill was placed along this beach in 1957, the fill material being obtained from the off-shore zone by conventional pipeline dredge. Analysis of data indicates that, in the three year period since placement of fill, wave action has transported a measurable quantity of the fill material from the beach zone to the offshore zone and that profile adjustment of the fill material is still in progress.
- (h) "Behavior of Beach Fill and Borrow Area at Prospect Beach, West Haven, Connecticut," by W. H. Vesper, Beach Erosion Board Technical Memorandum No. 127, 29 pages, 11 illus., 5 tables, August 1961.

(2659) LARGE SCALE TESTS OF WAVE FORCES ON PILING.

- (b) Laboratory project.
- (d) Experimental; applied research, design.
- (e) To determine the nature and magnitude of forces on piles caused by breaking and non-breaking waves.
- (g) Work has been continued on the data and a report is being prepared for presentation before Waterways and Harbors Division of ASCE.

(2660) WAVE TANK STUDY OF QUANTITY OF SEDIMENT IN SUSPENSION IN THE SURF ZONE (INCLUDING TEMPERATURE EFFECTS).

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) A vacuum pump-type suspended sediment sampler has been used to collect suspended sand samples under various laboratory conditions of waves, water temperature, and sand. The purpose of the study is to determine the relationship between wave, water, and sand characteristics, and the amount of material maintained in suspension and hence available for longshore transport by currents.
- (g) Suspended coal samples have been collected for the tests on "Equilibrium Profile of Beaches and Study of Model Scale Effects" (see Project No. 181).

(2661) WAVE RUN-UP ON SHORE STRUCTURES.

- (b) Laboratory project.
- (d) Experimental; design.
- (e) Wave run-up is determined experimentally by various waves for different types of shore structures. Effect of both structure roughness and permeability is being investigated.
- (g) Relatively large scale data have been taken on a 1 on 1 1/2 slope structure having a single layer of riprap, 3 layers of riprap, and a permeable rubble mound structure. These results indicate the probable existence of a scale effect for rubble structures (as has been previously indicated for smooth slopes). Further large scale data have been and are being taken on a 1 on 1 1/2 slope structure with a cover layer of (75-pound) quadripods. These data are to be compared with results of small scale tests at WES. Diagrams correcting small scale laboratory determined run-up curves for scale effect have been prepared and published.
- (h) "Shore Protection Planning and Design," Technical Report No. 4, Beach Erosion Board, Corps of Engineers, Page 89b-89l, 1961.

(2916) WAVE AND SURGE FORECASTING RELATIONSHIPS AND TECHNIQUES.

- (b) Laboratory project.
 - (d) Theoretical; basic research.
 - (e) To determine methods of predicting wave and storm surge characteristics.
 - (g) Studies and investigations of methods and application of methods for hurricane surge predictions have been continued. Work has continued on relating wave height and period to the wave spectrum. A few paper chart wave records have been analyzed to obtain wave heights and periods, from which wave spectra are computed and an attempt is being made to correlate these records with those analyzed for the same period by use of the wave spectrum analyzer.
 - (h) "A One-Dimensional Gravity Wave Spectrum," paper by Charles L. Bretschneider, Conference on Ocean Wave Spectra, Easton, Maryland, May 1-4, 1961.
 "The Beach Erosion Board Wave Spectrum Analyzer and Its Purpose," paper by Joseph M. Caldwell and Leo Williams, Conference on Ocean Wave Spectra, Easton, Maryland, May 1-4, 1961.
 "Utilization of Wave Spectra in Shore Processes," paper by Joseph M. Caldwell, Conference on Ocean Wave Spectra, Easton, Maryland, May 1-4, 1961.
- (3228) MODEL TESTS OF WAVE SETUP ON BEACHES.
- (b) Laboratory project.
 - (d) Experimental.
 - (e) To relate increase in water level at the shore due to wave action alone to the incident wave characteristics and shore hydrography.
 - (g) Additional tests have been made on a 1 on 15 slope and indicate a wave setup of the same order as that for the 1 on 30 slope. Tests in general indicate a wave setup at the shoreline of about 10% to 15% of the wave height for profiles of 1 on 15 or gentler, with little or no setup for slopes steeper than about 1 on 6. Small scale laboratory data also indicate that a submerged offshore barrier may substantially increase the wave setup at the shore.
 - (h) "Experimental Determination of Wave Setup," by Thorndike Savill, Jr., 2nd Technical Conference on Hurricanes, Miami Beach, Florida, June 1961.
- (3897) RADIOACTIVE TRACERS FOR BEACH STUDIES.
- (b) Laboratory project.
 - (d) Experimental; research.
 - (e) A natural or simulated sediment on or in which a radioisotope has been incorporated is to be placed at predetermined points along a sandy beach in the Shore Processes Test Basin. Wave induced currents will transport these labelled particles and periodically the beach and offshore zone will be monitored with appropriate detection instruments. In this manner a time-spaced history of the labelled particles will be determined. From the time-space history and other data it is hoped to develop further information concerning the mechanics of particle and littoral movement. Experience gained from the laboratory testing program will be utilized when field testing is undertaken.
 - (f) An application for license is being prepared for submission to the A.E.C. in order that testing may begin during the spring of 1962.
 - (h) "Preliminary Considerations of the Use of Radioisotopes for Laboratory Tracer Techniques," Norman E. Taney, Annual Bulletin of the Beach Erosion Board, Volume 14, pp. 16-27, July 1960.
- (3898) SCOUR CAUSED BY WAVES STRIKING SEAWALLS OR BULKHEADS.
- (b) Laboratory project.
 - (d) Applied research.
 - (e) The effect of waves acting against a vertical bulkhead on a sand beach in eroding or building up the beach.
- (g) The 0.2 mm sand used on the beach in the last year's tests was replaced by 0.4 mm sand and the test series was repeated to determine the effect of sand size.
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- U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, PORTLAND, Bonneville Hydraulic Laboratory.
- Inquiries concerning Projects Nos. 190, 2662, 3575, 3576, 3577, 3578, 3899, 3901, and 4379, should be addressed to the District Engineer, U. S. Army Engineer District, Walla Walla, Building 602, City-County Airport, Walla Walla, Wash.
- (190) MODEL STUDY OF SPILLWAY FOR McNARY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
 - (d) Experimental; for design.
 - (e) Hydraulic performance of the spillway and stilling basin was studied in a 3-bay, 1:36-scale sectional model. Flow conditions and pressures over the spillway were checked in a 1:10-scale model of a typical interior spillway bay and later were re-checked in the prototype.
 - (f) Tests have been completed.
 - (g) The model studies resulted in revisions that reduced the 24-bay spillway to 22 bays, streamlined the noses and narrowed the width of crest piers from 12 ft. to 10 ft., lessened danger of cavitation adjacent to gate slots, and shortened the 325-ft.-long stilling basin to a length of 248 ft. Maximum allowable gate openings were established for safe pressures on the baffle piers. Model and prototype pressures showed good agreement on the crest and piers, but pressures on the baffle piers were not directly comparable because they were measured under different tailwater conditions.
 - (h) "Spillway and Stilling Basin for McNary Dam, Columbia River, Oregon and Washington," U. S. Army Engineer Bonneville Hydraulic Laboratory Technical Report No. 21-1, June 1961. (Available on loan).
- (403) MODEL STUDY OF LOOKOUT POINT SPILLWAY, MIDDLE FORK WILLAMETTE RIVER, OREGON.
- (b) U. S. Army Engineer District, Portland, Corps of Engineers, 628 Pittock Block, Portland 5, Oregon.
 - (c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
 - (d) Experimental; for design.
 - (e) Approximately 2000 ft. of forebay area upstream from the dam, a 2200-ft. section of 250-ft.-high earth embankment, the 1900-ft.-long, uncontrolled side-channel spillway with 725-ft.-long ogee and 150-ft.-wide stilling basin, and 2400 ft. of downstream river bed were reproduced in a 1:72-scale model. Later a gravity spillway 149 ft. wide having 5 tainter-type crest gates was tested in the model.
 - (f) Tests have been completed.
 - (g) Suitable designs were developed for all elements of the spillway and stilling basin.
 - (h) "Side-Channel Spillway and Outlet Works for Lookout Point Dam, Middle Fork Willamette River, Oregon," U. S. Army Engineer Bonneville Hydraulic Laboratory Technical Report No. 24-1, November 1961. (Available on loan). A final report covering tests on the gravity spillway and regulating outlets (adopted designs) is scheduled for publication early in 1962.
- (404) MODEL STUDY OF LOOKOUT POINT TUNNEL, MIDDLE FORK WILLAMETTE RIVER, OREGON.
- (b) U. S. Army Engineer District, Portland, Corps of Engineers, 628 Pittock Block,

- (c) Portland 5, Oregon.
District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
- (d) Experimental; for design.
- (e) A 1:25-scale model included a portion of the forebay, the intake tower and tunnel entrances, the 20-ft. flood-control and 27-ft. power tunnel, Howell-Bunger regulating valves, and a portion of the tailbay area. Tests made to study the hydraulic characteristics of the outlet works included measurements of discharges, pressures, and velocities as affected by alignment slopes of entrances, and type and location of control valves.
- (f) Tests have been completed.
- (g) Satisfactory dissipation of energy was achieved in the outlet tunnel by discharging through hooded Howell-Bunger valves or tilted tainter valves installed in a six-lateral outlet manifold. Flow conditions in the power tunnel were acceptable unless the discharge exceeded 39,800 cfs or a single emergency gate was operated at partial openings under high heads. Conduits through a gravity spillway have been adopted instead of the design which was tested.
- (h) "Side-Channel Spillway and Outlet Works for Lookout Point Dam, Middle Fork Willamette River, Oregon," U. S. Army Engineer Bonneville Hydraulic Laboratory Technical Report No. 24-1, November 1961. (Available on loan).
- (2662) GENERAL MODEL STUDY OF JOHN DAY LOCK AND DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineering District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
- (d) Experimental; for design.
- (e) A fixed-bed model constructed to an undistorted scale of 1:80 reproduces the Columbia River bed from Mile 213.7 to 216.8. The dam axis is at Mile 215.6. The original structures layout consists of a straight, 20-bay, gravity-type spillway controlled by 50- by 58.5-ft. tainter gates, a powerhouse for 20 Kaplan turbines (initial installation 10 units), an 86- by 675-ft. navigation lock having a maximum lift of 113 ft., a concrete nonoverflow section, rock-fill abutments, and facilities for passing anadromous fish over the dam. Cofferdams having steel cells in the river legs and earth-and-rock shore connections are designed to withstand river flows to 700,000 cfs during first- and second-stage construction periods and 300,000 cfs during third-stage diversion. Purposes of the model study are to check the structures alignment and flow conditions affecting power generation, cofferdam placement, and fish passage.
- (g) Satisfactory designs were developed for both the first- and second-step cofferdams as a result of tests made in the model. Although flow patterns adjacent to the main structures were fairly satisfactory, realinement of the downstream approach channel improved conditions for navigation, and extension of a training wall between the spillway and powerhouse reduced a possible hazard for fish migrating upstream. Detailed studies of powerhouse tailrace alignments, south fishway entrance, and a pump house to provide auxiliary attraction water for the powerhouse fish collection system were made. Additional tests with a revised second-step cofferdam, right bank fills adjacent to and upstream from the navigation lock, highway detour fill, and extended river side downstream lock guard wall are in progress.
- (3230) MODEL STUDY OF NAVIGATION CHANNEL IMPROVEMENT AT BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineering District, Portland, Corps of Engineers, Portland, Oregon.
- (c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
- (d) Experimental; for design.
- (e) A 1:130-scale, undistorted, fixed-bed model reproduces 5.6 miles of the Columbia River adjacent to the dam site. The original layout includes existing structures and river bed (survey made in summer and fall of 1958). The purpose of the model is to study methods for improving navigation conditions in the approaches to Bonneville lock for seagoing vessels. A remotely-controlled model of a C-2 freighter is used to assist evaluation of flow conditions in the navigation channel.
- (f) Inactive. Tests of downstream approach have been completed.
- (g) After verification for existing conditions (1958), tests were made to determine effects of 1959 dredge cuts in the lock approach together with alternative improvement plans (rock-fill or concrete groins, permeable guard walls or dykes, and partial revision of the lock approach). None of the preliminary plans was satisfactory, and approximately 15 major channel revisions were tested singly or in combinations in efforts to provide the most practical and economical solution to the problems involved. Prototype construction of the most desirable plan, which consisted of excavating about 900,000 cu. yds. at the downstream end of Bradford Island, 180,000 cu. yds. along the Oregon shore, and 100,000 cu. yds. at the north side of the lock approach, was completed in 1961.
- (h) Final report is in preparation.
- (3575) MODEL STUDY OF JOHN DAY NAVIGATION LOCK, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
- (d) Experimental; for design.
- (e) A 1:25-scale model reproduced the 86- by 675-ft. lock chamber, split lateral filling and emptying systems, river outlet for emptying system, and portion of the upstream and downstream approach channels. Sufficient upstream approach area was simulated to permit investigation of vortex action over intake manifolds.
- (f) Tests have been completed.
- (g) With no spillway flow, undesirable vortex action over the intake manifolds of original design was eliminated in the model by reversing the left intake so that flow was drawn from the spillway side of the lock wall. Although additional tests, in which the model forebay was enlarged to include two spillway bays adjacent to the navigation lock, indicated that simultaneous operation of the lock and spillway created slight tendency toward vortex formation over the left intake, no further design changes were indicated. Tests to improve flow distribution within the lock chamber resulted in adoption of a lateral culvert design with sloping ports and roof overhang that varied from 2.25 ft. adjacent to a longitudinal culvert, to 1.0 ft. at the opposite end. The final design lock chamber was filled in 11.7 min. and emptied in 13.8 min. under an initial head of 113 ft. Average maximum longitudinal forces on an 8-barge tow (simulated displacement 11,070 tons) were about 3.5 tons and 2.0 tons during filling and emptying operations, respectively. Lateral forces on barge tows ranged from 1.0 to 1.5 tons.
- (h) Final report is in preparation.
- (3576) MODEL STUDY OF NORTH FISH LADDER DIFFUSERS, JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
- (d) Experimental; for design.

- (e) A 1:8-scale model reproduced diffusers 3 through 6, ladder weirs 155 through 163, and a section of the auxiliary water-supply conduit. A constant flow of 100 cfs will pass down the 24-ft.-wide, 1-on-10 sloped fish ladder; the water-supply conduit will supply from 600 to 1300 cfs as tailwater rises to maintain transportation flow in fish ladder. Provision was made in the model for measurement of outflows from the ladders, the water-supply conduit, and individual diffusers. The model was constructed so that most details of the weirs, diffusion chambers, expansion wells, and control orifices could be studied separately.
 - (f) Tests have been completed.
 - (g) The effects of level, stepped, and sloping diffuser floors were evaluated. Horizontal orifices on vertical separators within the expansion wells were found to be a practical means of automatically providing scheduled diffuser flows for a wide range of tailwater fluctuations within the fish ladder.
 - (h) Final report is in preparation.
- (3577) GENERAL MODEL STUDY OF LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
 - (d) Experimental; for design.
 - (e) A 1:100-scale, undistorted, fixed-bed model reproduces approximately 2.4 miles of Snake River bed and overbank topography at the dam site. The dam axis is at River Mile 41.5, about 60 miles from the city of Pasco, Washington. Studies will be made to determine flow conditions during various construction stages and after proposed structures have been installed.
 - (g) After verification of the model, studies of successive construction stages were made. It was found that proposed limits for excavation along the right bank were inadequate, revisions in alignment and height of first-step cofferdam cells were needed, and problems concerning fish passage would arise during each phase of construction. Numerous conferences and demonstrations held on the model helped solve problems regarding fish migrations. Tests on the proposed structures are in progress.
- (3578) MODEL STUDY OF FISH LADDERS FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
 - (d) Experimental; for design.
 - (e) An existing 1:10-scale fish ladder model was revised to reproduce 32 pools of 24-ft.-wide ladder sloped 1 on 10. Tests were being made to develop a design which will provide flow conditions comparable to those in a 1-on-16 slope, 24-ft.-wide ladder after which model will be revised to study the orifice-controlled regulating section of fish ladder.
 - (g) Velocities, flow patterns, and surge characteristics were determined for fixed-weirs of several alternative designs. The model was then revised to include the fishway exit, orifice control section, fish counting station, and eight typical weirs. In subsequent tests, orifice sizes for nonoverflow bulkheads within the orifice control section (two orifices per bulkhead) were adjusted to provide a uniform head drop between successive pools for an 11-ft. variation in forebay level. Current tests are concerned with the desirability of adding a third orifice in each bulkhead in order to facilitate the upstream migration of blue-back salmon and shad.
- (3899) MODEL STUDY OF SPILLWAY FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
 - (d) Experimental; for design.
 - (e) The 1:42.47-scale model includes a 3-bay section of the 8-bay spillway and stilling basin. Tests are being made to evaluate hydraulic performance of the proposed spillway and, if necessary or desirable, to develop revisions in design that will increase performance or reduce construction and maintenance costs.
 - (f) Tests of the stilling basin have been temporarily suspended pending derivation of a revised tailwater rating curve for the project.
 - (g) Satisfactory design of spillway crest, piers, and abutments, and determination of pressure data and discharge rating curves for free and gated flows were accomplished. Abutment contraction coefficients were determined with and without a simulated powerhouse structure in place. With a maximum head of approximately 65 ft., an abutment coefficient of 0.0335 was indicated for a half pier adjacent to the powerhouse, whereas a value of 0.0365 was derived for the opposite abutment.
- (3900) MODEL STUDY OF DOWNPULL FORCES ON EMERGENCY CLOSURE GATES.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
 - (c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
 - (d) Experimental; applied research.
 - (e) This is a general study of various sluice coaster gate bottom and lip shapes, and includes downpull and discharge measurements as affected by angle of gate bottom, length of gate lip extension, control valve opening, number of control valves operated, and conditions of air vents (open or closed). A 1:25-scale model reproduces a level approach to an intake tower with vertical headwall normal to intake center line, two three-sided bellmouth intakes, a 20-ft.-wide by 22-ft.-high emergency gate (tractor type), two 10-ft.-wide by 15-ft.-high control valves (tainter), and a 22-ft.-diam. outlet tunnel. Hydraulic downpull forces are computed from pressures at 21 critical locations on the emergency gate.
 - (f) Tests have been completed.
 - (g) Downpull forces were measured on a tractor-type emergency closure gate with bottom beam sloped 30, 37.5, and 45 degrees and with lip extensions of 0, 3.5, 8, and 12 in. under heads between 50 and 300 ft. Downpull forces were highest with the 30-degree bottom and lowest with the 45-degree bottom. Although lip extensions reduced the downpull, their effectiveness decreased as the bottom slope was increased.
 - (h) Final report is in preparation.
- (3901) MODEL STUDY OF LOW-BAY SPILLWAY FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
 - (d) Experimental; for design.
 - (e) The 1:24-scale model includes two low spillway bays and stilling basin for John Day Dam. Tests were made to determine a design for the downstream lip of low bay that would eliminate scouring during second-stage diversion. Tests will also be made to determine scouring conditions for several low-bay elevations to assist in low-bay design for other projects.
 - (f) Inactive. Tests have been suspended.
 - (g) In tests that simulated second-stage diversion through the low bays of John Day Dam, scouring action within the stilling basin was minimized by terminating the low bays with a vertical strip that extended about 7.5 ft. downward to the spillway bucket. The tests were extended to several low-bay elevations

- to determine the influence of tailwater depth and discharge on scouring action within the stilling basin and spillway bucket.
- (h) Results of this study will be included in final report on (3229) Model Study of Spillway for John Day Dam, which is in preparation.
- (4379) MODEL STUDY OF LOWER MONUMENTAL NAVIGATION LOCK, SNAKE RIVER, WASHINGTON.
- (b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
- (d) Experimental; for design.
- (e) A 1:25-scale model reproduces a typical 86-by 675-ft. lock chamber, split lateral filling and emptying system, river outlet for emptying system, and portions of the upstream and downstream approach channels. The model forebay includes the short nonoverflow section between spillway and navigation lock, and two adjacent spillway bays to permit investigation of vortex action over the staggered intake manifolds when filling the lock with or without spillway flow.
- (g) Preliminary test results indicate that vortices may occur over the right intake during a portion of the filling operation. Eddy currents along the left guard wall were dissipated before they could join and form vortices. Continuing studies of vortex action are in progress.
- (4380) MODEL STUDY OF SPILLWAY FOR GREEN PETER DAM, MIDDLE SANTIAM RIVER, OREGON.
- (b) U. S. Army Engineer District, Portland, Corps of Engineers, 628 Pittock Block, Portland 5, Oregon.
- (c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
- (d) Experimental; for design.
- (e) A 1:50-scale model includes 1540 ft. of the forebay area, the 2-bay spillway and flanking abutments, outlet conduits, stilling basin, powerhouse tailrace, and approximately 1620 ft. of river channel downstream from the project. The spillway model will be used to determine the adequacy of the stilling basin design, the spillway crest, pier, and abutment details, the location of tailwater gate trunnions and outlet eyebrows, and will provide data needed for design of a training wall between the powerhouse tailrace and the stilling basin.
- (g) Tests to date indicate the need for revisions in designs of the abutments, training walls, and stilling basin. Improved designs for these elements are being developed.
- (4381) TESTS OF RUBBER MITER GATE BOTTOM SEALS FOR PANAMA CANAL.
- (b) U. S. Army Engineer District, Seattle, Corps of Engineers, Seattle Washington.
- (c) District Engineer, U. S. Army Engineer District, Seattle, 1519 South Alaskan Way, Seattle 4, Washington.
- (d) Experimental; for design.
- (e) The Panama Canal miter gates vary in height from 47.3 to 82.0 ft., and the head on closed gates ranges from 0 to 80.0 ft. The miter gate sills were originally built of timber beams supported continuously on iron angles in the concrete. The gate leaves carried a timber bumper that fitted closely against the timber sill to form a bottom seal. It is proposed that the timber bumpers will be replaced by butting-type rubber seals attached along a bottom girder on the downstream side of each miter gate. The proposed rubber seal "floats" between a continuous upper seal plate and 1-ft.-long lower angle brackets spaced 2 ft. apart. The rubber seal is retained by 1-in. bolts through 4-in.-diam. holes spaced on 4-ft. centers in the seal web. Eight rubber seal sections, each 5 ft. in length, will be tested in a pressure tank to determine: (a) the head differential required to seat the seal against the sill plate; (b) leakage of seal at various heads from just seating to a maximum of 80 ft; (c) effect of changing 1/4-in. clearance between the proposed angle-bracket seal supports; (d) effect of irregularities in straightness of rubber seal and sill plate, and of simulated debris between seal and sill; (e) head required to cause "blow by" between gate leaf and sill; and (f) effect of increasing rubber seal flotation by adding polyvinyl chloride unicellular foam to the rubber seal core holes.
- (g) Design and construction of test apparatus are in progress.
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- U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, St. Paul.
- (194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.
- U. S. Army Engineer District, St. Paul and U. S. Geological Survey, in cooperation with St. Anthony Falls Hydraulic Laboratory. See St. Anthony Falls Hydraulic Laboratory, page 65.
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- U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.
- Inquiries concerning the following projects should be addressed to the Director, U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, P. O. Box 631, Vicksburg, Miss.
- (236) MISSISSIPPI BASIN MODEL.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; for design.
- (e) The project provides for construction and operation of a model of the Mississippi River watershed including the Missouri, Ohio, Tennessee, Cumberland, and Arkansas Rivers and their principal tributaries. The model area comprises 200 acres and reproduces 1,250,000 square miles of the Mississippi Basin. The topography of the streams and flood plains is being reproduced to a horizontal scale of 1:2,000 and vertical scale of 1:100. All existing and proposed flood-control reservoirs, dikes, floodwalls, and other pertinent works will be reproduced in the portion constructed of concrete. The completed construction in concrete consists of the Upper Mississippi River from Hannibal, Missouri, to Baton Rouge, Louisiana; the Missouri River from Sioux City, Iowa, to the mouth; the Ohio River from Louisville, Kentucky, to the mouth; the Tennessee River from Pickwick Dam, Tennessee, to the mouth; the Cumberland River from Old Hickory Dam, Tennessee, to the mouth; and the Arkansas River from Blackburn Dam Site, Oklahoma, to the mouth. Water-surface elevations are measured by electrically operated stage devices with the recorders located in central control buildings. Streamflow is introduced and controlled by automatic instruments called inflow controllers. The model was designed to aid in the development of coordinated basinwide plans for flood control and operation of flood-control structures.
- (g) The extent of model operation each year is determined by the testing programs directed by the Mississippi Basin Model Board and Chief of Engineers and requested by Divisions and Districts that have operable sections on the model. The model was operated as an integrated unit for comprehensive (basinwide) tests: tests were conducted of the 1937, 1943, 1945, and 1950 floods using the actual floods with present-day conditions and the same floods without reservoir modification

- and with modification by the existing reservoirs and those scheduled for completion in the near future (approximately 1970). Tests were conducted to verify the Memphis, Tennessee, to Vicksburg, Mississippi, reach to the 1945 and 1950 floods. Tests were conducted by the U. S. Army Engineer Division, Ohio River, to assist in determining the roughness conditions that will exist in the Barkley and Cheatham Reservoirs after completion of Barkley Dam.
- (h) "Verification of the Pickwick Dam-Kentucky Dam Reach, Tennessee River and Tributaries, 1950 and 1948 Floods," Mississippi Basin Model Report 13-1, (December 1960). "Flood-Routing and Reservoir-Operation Study, Tulsa-to-Van Buren Reach, Arkansas River and Tributaries," Mississippi Basin Model Report 24-1, (April 1961).
- (425) COMPREHENSIVE MODEL STUDY, DELAWARE RIVER, PENNSYLVANIA.
- (b) District Engineer, U. S. Army Engineer Dist., Philadelphia, Corps of Engineers, Phila., Pa.
- (d) Experimental; for design.
- (e) To develop and test plans for reduction of shoaling in several ranges of the navigation channel, the entire Delaware River estuary from the Atlantic Ocean to Trenton is reproduced in the model which is of the fixed-bed, silt-injection type, with scale ratios of 1:1,000 horizontally and 1:100 vertically. Tides and tidal currents are reproduced by automatic tide generators. Observed prototype salinities are reproduced in the Delaware Bay portion of the model and provisions made for the injection of silts, and for measuring silt deposits. Studies are also made of salinity intrusion and the dispersion and dilution of wastes discharged into the estuary.
- (f) Suspended.
- (993) CAVITATION RESEARCH.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) The cavitation characteristics of such elements as baffle piers, steps in stilling basins, spillway and conduit gate slots, and offset joints are studied in either a vacuum tank or a variable-pressure, closed-jet water tunnel. The investigation includes a review of literature to evaluate the many variables that affect cavitation results. A high-velocity water facility was constructed to study the resistance of protective coatings on cavitation-damaged concrete specimens.
- (994) EFFECTS OF MODEL DISTORTION.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) This is a general study to determine the hydraulic effects of various types and degrees of model scale distortion on velocity distribution and other hydraulic conditions, with the ultimate aim of establishing limits of permissible distortion for the various types of models. Tests are in progress of a rectangular flume having a 90-degree bend with provisions for changing the vertical scale to provide a distortion of 0 to 10.
- (999) STABILITY OF RUBBLE-MOUND BREAKWATERS.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) Rubble-mound structures are studied in a 5-by 4- by 119-foot wave tank to develop formulas, supported by experimental data, from which the design of safe and economical breakwaters can be determined. In addition to quarrystone, tetrapods, tetrahedrons, tribars, and other specially molded armor units are being studied.
- (g) The results of stability tests on pell-mell-placed protective cover layers of quarrystone, tetrapod, tribar, hexapod, modified cube, and tetrahedron armor units are represented with very good accuracy by the formula
- $$W_r = \frac{\gamma_r H^3}{K_\Delta (S_r - 1)^3 \cot \alpha}$$
- where W_r is weight of individual armor units, γ_r is the specific weight of the armor units, H is height of selected design wave, S_r is the specific gravity of armor units relative to the fluid in which the structure is located (γ_r/γ_w), α is the angle of the breakwater face measured from the horizontal, and K is a dimensionless coefficient. The results of stability tests on conical wrap-around breakwater heads indicated that the weight of quarrystone armor units used for construction of the head should be heavier than units used on the trunk. Comparison of the weights of rough and smooth quarrystones required for stability showed that the weight of smooth quarrystones should be considerably greater than the weight of rough quarrystones.
- (h) "Wave Forces on Rubble-Mound Breakwaters and Jetties," U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-453, September 1961. (Available on loan.)
- (1002) EFFECTS OF SCALE AND OPERATING TECHNIQUES ON HARBOR WAVE ACTION MODELS.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) Tests are conducted in flumes and harbor model basins to obtain information that will allow more accurate determination of optimum scales for wave models, and the effects of different scale and operating techniques on the accuracy of model results. The efficiency of flexible-element wave filters is being investigated to facilitate continuous operation of wave flumes. Resonant chambers for harbor entrances and attenuation of waves in a three-dimensional model are being studied.
- (1004) INSTRUMENTATION.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; development.
- (e) Various types of measurement and control equipment for use in hydraulic studies are being developed. These include equipment for measuring subsurface currents and for operation of a model boat by remote control. The development of miscellaneous model and field measuring instruments was continued as the need arose.
- (1211) MODEL STUDY OF HOOSIC RIVER, NORTH ADAMS, MASSACHUSETTS.
- (b) District Engineer, U. S. Army Engineer District New York, Corps of Engineers, New York, N.Y.
- (d) Experimental; for design.
- (e) A 1:30 model was used to verify the hydraulic design for improvement of certain sections of the North and South Branches of Hoosic River in North Adams, Massachusetts, and to determine whether changes should be made for safety, increased efficiency, or economy. The flow in the major portion of these channels will be below critical depth. The model was used to check such design features as channel alignment, transitions, super-elevation in bends, characteristics of weirs, stilling basins, drop structures, the treatment of intakes and outlets, wall heights, and elevations of bridges.
- (h) Final report in preparation.

- (1467) ANALYSIS OF HYDRAULIC EXPERIMENTAL DATA (MODEL AND PROTOTYPE) AND DEVELOPMENT OF DESIGN CRITERIA.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
 - (d) Analytical (model and prototype); for design.
 - (e) A general study to develop, analyze, and disseminate to Corps of Engineers establishments hydraulic design criteria to insure adequate capacity, economy of design and construction, and safe and satisfactory operation. Criteria are developed from model and prototype tests relating to the design of spillways, outlet works, gates and valves, channels, and navigation structures.
 - (g) "Hydraulic Design Criteria" charts have been prepared on constant friction damping, velocity distribution in the hydraulic jump, spillway flip bucket pressures and throw distances, low ogee crest shapes, morning glory spillways, gate slot pressures, entrance shapes and pressures for earth dam outlet works, ice thrust on hydraulic structures, and head losses for thin plate orifices in surge tanks.
 - (h) "Hydraulic Design Criteria" Issue No. 11 (available for purchase in limited quantities).
- (1474) OPERATING FORCES OF MITER-TYPE LOCK GATES.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
 - (d) Experimental; applied research.
 - (e) A general study to collect basic data on operating forces of miter-type lock gates and to determine the effect of various elements upon these forces was conducted in a 1:20 model. A lock chamber 110 feet wide was reproduced with provisions for varying the length up to 600 feet on each side of the gate. Forces required for operation of miter gates were measured for variations of the following elements: gate leaves, speeds and accelerations of operation, submerged depths, recess shapes, bottom clearances, chamber lengths, and nonsynchronous operation of gate leaves. Variations in the type linkage driving the gate were also investigated.
 - (h) Final report in preparation.
- (1475) SIPHON ACTION AT PUMPING PLANTS.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
 - (d) Experimental; applied research.
 - (e) This study was conducted to aid in developing design criteria for pumping plants that depend on development of siphonic action in the discharge side of the pumps in order to yield the required discharge. Full-size models of a 6-inch and 12-inch plastic discharge line were tested. Variables investigated during the tests were: rates of flow, water levels in the discharge side of the pumps, slope and length of the riverward leg, and venting conditions at the crown.
 - (h) Final report in preparation.
- (1738) MODEL STUDY OF SPILLWAY AND STILLING BASIN, GREENUP LOCKS AND DAM, OHIO RIVER.
- (b) District Engineer, U. S. Army Engineer District, Huntington, Corps of Engineers, Huntington, W. Va.
 - (d) Experimental; for design.
 - (e) A 1:25 section model reproducing 400 feet of the approach area, a portion of the spillway crest and stilling basin, and 500 feet of the exit area was used to examine hydraulic performance of the spillway and stilling basin. A second phase of the study involved the measurements of hydraulic forces acting on a submergible-type spillway tainter gate.
 - (f) Completed.
 - (g) The recommended stilling basin consists of a horizontal apron 74 feet long with a single row of baffle piers located 49 feet from toe of gate sill and a 4-foot-high stepped end sill. In development of this design, which was satisfactory for both nonsubmergible and submergible types of gates, consideration was given not only to bottom velocities in the exit channel, but also to the types of flow conditions produced. The submergible gate was stable throughout the range of operating conditions, and model hoist loads agreed with computed loads.
 - (h) "Spillway, Greenup Locks and Dam, Ohio River, Kentucky and Indiana; Hydraulic Model Investigation," U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-572, July 1961. (Available on loan.)
- (1739) MODEL STUDY OF GATE AND STILLING BASIN, MARKLAND LOCKS AND DAM, OHIO RIVER.
- (b) District Engineers, U. S. Army Engineer Districts, Huntington and Louisville, Corps of Engineers, Huntington, West Virginia, and Louisville, Kentucky.
 - (d) Experimental; for design.
 - (e) A 1:25 section model reproducing 400 feet of the approach area, a portion of the spillway crest and stilling basin, and 500 feet of exit area was used to examine hydraulic performance of the low sill spillway surmounted by submergible and nonsubmergible tainter gates, and of the stilling basin below each type gate. Of special interest were gate hoist loads and vibration tendencies. A 1:4 model of a section of the face of the submergible gate and downstream face of the sill was used for detailed study of pressure conditions and observation of behaviour of an inflatable bottom seal for the gate.
 - (f) Completed.
 - (g) Loads on the submergible gate due to hydraulic forces were not excessive, and with its top shaped to ensure positive pressures, oscillation of the gate is unlikely. The 1:4 model revealed that the gap between the gate face and sill must not flare more than 1 inch to maintain relatively stable pressures on gate and sill. The inflatable bottom seal was not satisfactory. In development of the stilling basin below the submergible gate, rearrangement of basin elements was required to obtain adequate stilling action and avoid the possibility of undesirable types of action. This basin was also satisfactory for the nonsubmergible gate.
 - (h) "Spillway for Markland Locks and Dam, Ohio River, Kentucky and Indiana; Hydraulic Model Investigation," U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-566, May 1961. (Available on loan.)
- (1986) SALT WATER INTRUSION AND RELATED PHENOMENA.
- (b) Committee on Tidal Hydraulics, Corps of Engineers (correspondence should be addressed to Mr. J.B. Tiffany, Chairman, Committee on Tidal Hydraulics, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.).
 - (d) Experimental; applied research.
 - (e) To determine the effects of salinity and related phenomena on the vertical distribution of currents and shoaling characteristics in estuaries, tests are being made in a lucite flume 327 feet long, 1.5 feet deep, and 0.75 foot wide. One end of the flume is connected to a 25-foot-square tidal basin in which any desired tide can be produced and in which the salinity can be controlled. The opposite end is connected to a fresh-water source. Combinations of flume roughness, tidal range, tidal period, source salinity, mean depth, and fresh-water inflow are studied. A total of about 10 tests were made during the year. The results are being analyzed; however, no conclusions have been reached at this time.
 - (h) "One-Dimensional Analysis of Salinity Intrusion in Estuaries," Committee on Tidal Hydraulics Technical Bulletin No. 5, June 1961. (Available on loan.)

(1987) RIPRAP PROTECTION AT HYDRAULIC STRUCTURES.

LAWRENCE RIVER.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) The study of erosion characteristics of various sizes of riprap and gravel material is being performed with a view to securing adequate protection at minimum cost. Measurements of velocity and turbulence at which movement of material begins will be made. At present, tests are being conducted on various sizes of riprap below a high structure and a low, navigation-type structure to determine the flow characteristics at which movement occurs.
- (g) As expected, preliminary results indicate turbulence as well as velocity to be a critical factor in riprap failure.

- (b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.
- (d) Experimental; for design.
- (e) Two fixed-bed models were used to study plans for navigation improvement in the lower portion of the international Rapids section of the St. Lawrence River. A 1:100 model of the Cornwall Island Reach reproduced all features of the river from just below the tailrace of the proposed Barnhart Island powerhouse to about the mid-point of Cornwall Island, and included portions of both the North, and South Cornwall Island Channels, Poiys Gut, and the entrance to Grass River locks. A model of the Barnhart Island-Lake St. Francis Reach, built to scales of 1:300 horizontally and 1:100 vertically, reproduced a greater area upstream and downstream of Cornwall Island. Both models were used to study navigation conditions in the approach to the Grass River locks, proposed plans for excavations in both Cornwall Island channels to effect navigation improvement in South Channel, and to determine conditions that will be encountered by navigation during the construction of the project features in the Cornwall Island Reach.

(1988) WATER TEMPERATURE EFFECTS ON BED FORMS AND ROUGHNESS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) A laboratory flume, in which water temperatures can be varied to simulate normally experienced summer and winter temperatures, is being used to investigate the effects of water temperature on streambed forms and roughness of various types of bed materials. Tests with fine sand are in progress.
- (g) Testing and analysis of results have not progressed sufficiently to permit the development of definite conclusions. Tentatively, the results available indicate that for a given rate of bed movement, the roughness of the bed and the water-surface slope are increased as the temperature of the water decreases.

- (f) Completed.
- (g) 1) A navigation channel in the South Cornwall Island Channel was designed to meet velocity criteria of 4.0 feet per second. 2) Optimum location of dredging to provide minimum velocities for specified time periods during construction of the project was determined. 3) Location and extent of dredging in the North Cornwall Island Channel required to maintain the natural distribution of flow between the North and South Cornwall Island Channels were determined. 4) Effects of over-all plan on the tailwater at Barnhart Island powerhouse were determined.
- (h) "Navigation Improvements in Barnhart Island-Cornwall Island Reach, St. Lawrence River; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-576, August 1961. (Available on loan.)

(2428) MODEL STUDY OF SAVANNAH HARBOR, GEORGIA.

- (b) District Engineer, U. S. Army Engineer District, Savannah, Corps of Engineers, Savannah, Georgia.
- (d) Experimental; for design.
- (e) The investigation was conducted in a model which reproduced the following: 1) that portion of the Atlantic Ocean, adjacent to the harbor entrance, from Calibogue Sound on the north to Wassaw Sound on the south; 2) the Savannah River and its flood plain to the head of tide at Ebenezer Landing; and 3) that portion of the Intracoastal Waterway which crosses the area included in the model. The model was of fixed-bed construction with scale ratios, model to prototype, of 1:800 horizontally and 1:80 vertically. Automatic tide generators were used to reproduce tides and tidal currents throughout the harbor, and salt water was used in the model ocean to reproduce the effects of density difference on current velocities and distributions. Shoaling studies were made by injecting finely ground gilsonite into the model to reproduce the patterns of shoaling as observed in the prototype, following which the effects of proposed improvement plans on shoaling patterns were observed and evaluated. Studies were also made of the effects of proposed improvement plans on dispersion and dilution of contaminants discharged into the harbor. Refinements of plans for reducing and localizing shoaling were tested.
- (f) Tests suspended.
- (h) "Savannah Harbor Investigation and Model Study," Volume III, "Results of Model Investigations"; Section 1, "Model Verification and Results of General Studies," and Section 2, "Tests of Improvement Plans." U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-580, October 1961. (Available on loan.) Preparation of Section 3 of final report in progress.

(2673) MODEL STUDIES OF BARKLEY LOCK AND DAM, CUMBERLAND RIVER, TENNESSEE.

- (b) District Engineer, U.S. Army Engineer District, Nashville, Corps of Engineers, Nashville, Tennessee.
- (d) Experimental; for design.
- (e) A 1:120 model, reproducing the Cumberland River from mile 29.4 to 32.2, the lock, dam, and powerhouse, was used to investigate flow characteristics in the approaches to the lock. A 1:36 model, reproducing the riverward downstream lock wall including the culvert manifold which discharges into the spillway stilling basin, five spillway bays, 324 feet of approach channel, and 596 feet of exit channel, was used to investigate flow characteristics in the stilling basin and exit channel. The emergency lock gate was studied in a 1:25 model which reproduced the gate, gate sill, and portions of the upstream lock approach and the lock chamber downstream from the gate. This model was used to determine: 1) hydraulic forces on and stability of the emergency gate under various flows including free flow over the lock miter sill; 2) hydrostatic forces on the gate in various positions; 3) gate wheel reactions and sill roller reactions at given positions; and 4) head loss through the bridge decking.
- (h) Final report in preparation.

(2675) MODEL STUDIES OF DARDANELLE LOCK AND DAM, ARKANSAS RIVER, ARKANSAS.

(2429) MODEL STUDIES OF THE CORNWALL ISLAND AND BARNHART ISLAND-LAKE ST. FRANCIS REACHES, ST.

- (b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers,

- Little Rock, Arkansas.
- (d) Experimental; for design.
 - (e) A 1:25 model reproduced only the initial construction features, i.e. the upstream lock approach, intakes, culverts to and including the location of the valves, and three spillway bays adjacent to the lock (the lock chamber was simulated schematically). The model also included one culvert valve to provide data on effect of gap between skin plate of valve and the seal plate for future design use. Tests were concerned with reduction or elimination of vortex tendencies at the wall intakes during filling, and alleviation of low pressures just downstream from the culvert valves.
 - (f) Completed.
 - (g) Tests showed that lengthening the intake area by adding three more ports in the upstream landwall and four in the riverwall reduced vortex action near the intakes to a minimum. Tests also revealed that control of the size of gap between the culvert valve skin plate and the seal plate is important in reducing low pressures just downstream from the valve, i.e. the smaller the gap, the better the pressure conditions. Water vent ports from the lock chamber to the culvert downstream from the valve helped reduce negative pressures but may not justify construction costs.
 - (h) "Intake Studies, Dardanelle Lock, Arkansas River, Arkansas; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-573, July 1961. (Available on loan.)
- (2678) MODEL STUDY OF NAVIGATION CONDITIONS, McALPINE LOCKS AND DAM, OHIO RIVER.
- (b) District Engineer, U. S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
 - (d) Experimental; for design.
 - (e) A fixed-bed, 1:120 model reproduced a six-mile reach of the Ohio River including adjacent overbank areas, the locks and dam structures, and all bridges and other structures that might affect flow conditions. Purposes of the model study were to: determine the effects of location, size, and alignment of the dam on stages and currents in the upper pool; determine the effects of location, size, and alignment of a new approach channel on navigation and surge conditions; determine the best location for a new navigable span on the Pennsylvania Railroad bridge; determine a method of operating the dam for optimum navigation conditions; study navigation conditions in the lower approach as affected by flow through dam, powerhouse, and lock-emptying system; and provide a means for navigation interests to satisfy themselves as to the acceptability of the proposed plan by observing the model in operation.
 - (f) Tests completed.
 - (g) Data were obtained to determine the effects of various dam designs on stage duration curves, head on the hydroplant, and velocities along the Indiana shore.
 - (h) Final report in preparation.
- (2680) MODEL STUDY OF HURRICANE TIDES IN NARRAGANSETT BAY, RHODE ISLAND.
- (b) Division Engineer, U. S. Army Engineer Division, New England, Corps of Engineers, Boston, Massachusetts.
 - (d) Experimental; for design.
 - (e) A fixed-bed model, 1:1,000 horizontally and 1:100 vertically, reproduces all of Narragansett Bay and an adjacent portion of the Atlantic Ocean. An automatic tide generator reproduces normal tides throughout the model, and a separate, manually operated generator reproduces hurricane tides or the desired characteristics at the bay entrance. Numerous barrier plans for prevention of hurricane-tide damage have been proposed. The relative and absolute effectiveness of these plans in reducing hurricane-tide elevations throughout the bay system were determined and the effects of the best plan on such important factors as tidal circulation, pollution, salinity, and shoaling for normal conditions were investigated. Fresh water only is used in the model during tests of the proposed barrier plans, but both salt and fresh water are used in tests to determine the effects of barrier plans on all significant factors for normal conditions. Model appurtenances consist of automatic tide gages to record both hurricane-tide and normal-tide elevations at critical points, recording salinity meters, recording dye meters for observing pollution and/or flushing characteristics, current velocity meters, and equipment for simulating shoaling of the channels and other navigation facilities.
 - (g) The results of supplemental tests indicate that a lower bay barrier plan can be designed which is acceptable to the Navy and which will afford most of the desired protection from hurricane surges.
- (2681) SCALE-EFFECT TESTS OF RUBBLE-MOUND BREAKWATERS.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
 - (d) Experimental; applied research.
 - (e) Tests are being conducted by the Beach Erosion Board, under the supervision of the Waterways Experiment Station, to investigate the effects of model scale on the results of experimentally determined criteria for the design of rubble-mound breakwaters. Stability tests are being made of a breakwater slope of 1 on 1-1/2 using wave periods of 2.61, 3.75, 7.87, and 11.33 seconds. Tests in the Beach Erosion Board wave flume (15 feet by 20 feet by 635 feet) are being conducted using a linear scale of 7.5 to 1 based on the tests conducted in the Waterways Experiment Station 5- by 4- by 119-foot wave flume. Stability tests have also been conducted in the Waterways Experiment Station small wave flume (1 foot by 1.5 feet by 94 feet) using a scale of 0.5 to 1 based on tests conducted in the 5- by 4- by 119-foot wave flume. Therefore, data on the stability of rubble-mound breakwaters will be available for three different linear scales, 0.5 to 1, 1 to 1, and 7.5 to 1. Test data from the Beach Erosion Board wave flume will be correlated with data from the Waterways Experiment Station flumes. Tests are being conducted using rough quarrystone and concrete quadripods.
- (2685) MODEL STUDY OF WAVE ACTION, SUPERIOR ENTRY, DULUTH-SUPERIOR HARBOR, LAKE SUPERIOR.
- (b) District Engineer, U. S. Army Engineer District, St. Paul, Corps of Engineers, St. Paul Minnesota.
 - (d) Experimental; for design.
 - (e) A 1:150 fixed-bed model was used that reproduced all the navigation approach channel and harbor breakwater structures as well as the inner harbor dock area serving Superior, Wisconsin, and included adjacent lake and shore-line areas to permit reproduction of storm waves from all critical directions. Investigations were made: to evaluate the wind-wave problems that cause ship damage in the vicinity of Superior Entry; and to develop the most effective remedy possible so that navigation and docking hazards now prevailing will be adequately remedied.
 - (g) Preliminary analysis of test results indicates that a detached breakwater 600 to 800 feet in length, the outer limit of which is located about 2,800 feet lakeward of the present harbor entrance, will provide adequate protection to the inner harbor from wave action.
 - (h) Final report in preparation.

(2925) ULTRASONIC FLOW MEASUREMENT.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; development.
- (e) Various types of acoustic flowmeter equipment for discharge measurement in closed rectangular and circular conduits are being investigated for proposed field application in large conduits and tunnels. Both line and point transducers are being evaluated.
- (f) Inactive. It is anticipated that all further work will be accomplished on specific full-scale structures.
- (g) A line-transducer type of acoustic flowmeter was installed and tested at Sutton Dam in a 5-foot-8-inch by 10-foot sluice. Certain modifications to the equipment were indicated desirable and are being made.

(2931) MODEL STUDY OF SOUTHWEST PASS, MISSISSIPPI RIVER.

- (b) District Engineer, U. S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisiana.
- (d) Experimental; for design.
- (e) To determine the effectiveness of proposed improvement works (jetty extensions, channel realignments, and contraction works) in eliminating or reducing the periodic maintenance now required in order for deep-draft vessels to navigate the jetty and bar channels of Southwest Pass, the lower 12 miles of the Pass and the adjacent area of the Gulf of Mexico were reproduced in a fixed-bed model to scale ratios of 1:500 horizontally and 1:100 vertically. Tides, tidal currents, littoral currents, and wave action in the Gulf of Mexico, and salt- and fresh-water flows in Southwest Pass and the bar channel were reproduced in the model. Shoaling studies were made by introducing various mixtures of plastic materials into the model to simulate prototype shoaling materials and thus reproduce in the model the patterns and distribution of shoaling that occur in the prototype.
- (h) Preparation of final report in progress.

(2932) MODEL STUDY OF HUDSON RIVER, NEW YORK.

- (b) District Engineer, U. S. Army Engineer District, New York, Corps of Engineers, New York, New York.
- (d) Experimental; for design.
- (e) A fixed-bed model constructed to linear scales of 1:100 vertically and 1:1,000 horizontally, is being used to determine the source of material shoaling the Hudson River in the vicinity of Edgewater and Weehawken piers and the most effective means of reducing or eliminating this shoaling. The model reproduces Upper and Lower New York Bays, Raritan Bay, Hudson River to Hyde Park, East River to Throgs Neck, and tributaries flowing into the modeled bodies of water. Provisions are made to reproduce tides, fresh-water discharge, salinity intrusion, and shoaling.
- (f) Suspended.
- (g) Tests of plans involving combinations of dikes and dredging to adjust the river cross section in the vicinity of the George Washington Bridge revealed significant reductions in shoaling in the 30-foot project channel and in the pier slips. However, some of these plans would cause an increase in shoaling in the 45- and 48-foot project channels. Shoaling tests of various locations and depths for sedimentation basin 1 showed that relocating the basin will not increase the basin shoaling rate, but an increase can be effected by deepening the basin.

(3233) MODEL STUDY OF SPILLWAY BULKHEADS, GREENUP DAM, OHIO RIVER.

- (b) District Engineers, U. S. Army Engineer Districts, Huntington and Louisville, Corps

of Engineers, Huntington, West Virginia, and Louisville, Kentucky.

- (d) Experimental; for design.
- (e) A 1:25 model of a solid, girder-type bulkhead with upstream and downstream skin plate and lifting beam was used to determine the vertical forces acting on the bulkhead and lifting beam as they are lowered in flowing water in one, two, three, or four units.
- (f) Completed.
- (g) Tests showed that the loads on the hoist due to hydraulic forces would be small and relatively stable when the four bulkhead units were joined into one unit and lowered through flowing water (proposed method of operation). Large unstable loads occurred when one bulkhead unit was placed at a time. Placing the bulkhead in two or three units would not cause unstable loads, but total hoist load would exceed that of the proposed method of operation.
- (h) "Spillway, Greenup Locks and Dam, Ohio River, Kentucky and Indiana; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-572, July 1961. (Available on loan.)

(3235) MODEL STUDY OF PIKE ISLAND LOCKS AND DAM, OHIO RIVER.

- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
- (d) Experimental; for design.
- (e) A 1:120, fixed-bed type, comprehensive model, reproducing about 4 miles of the Ohio River and the locks and dam structures, was used to select the most favorable site location by studying approach conditions under various river flows, and to develop modifications required to overcome any undesirable conditions at selected site.
- (f) Completed.
- (g) The investigation indicated that satisfactory navigation conditions could be obtained with the locks located along either the right or left bank of the river. Ports will be required in the upper guard wall at either location to minimize or eliminate the effects of the hazardous crosscurrents near the end of the wall and to facilitate the movement of tows entering and leaving the locks, particularly during higher river stages.
- (h) "Navigation Conditions at Pike Island Locks and Dam, Ohio River; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-577, August 1961. (Available on loan.)

(3236) MODEL STUDY OF MAXWELL LOCKS AND DAM, MONONGAHELA RIVER, PENNSYLVANIA.

- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
- (d) Experimental; for design.
- (e) A 1:120 fixed-bed type, comprehensive model, reproducing about 2.5 miles of the Monongahela River and the locks and dam structures, was used to study approach conditions under various river flows and methods of operation of control gates; to determine effects of design modifications required to overcome any undesirable conditions; to demonstrate to navigation interests the acceptability of the proposed design from a navigation standpoint.
- (f) Tests completed. Preparation of final report in progress.
- (g) Test results indicated the maximum discharges which could be passed without overtopping the cofferdams during various phases of construction, velocities with the cofferdams in place, and the effects of the cofferdams on navigation during construction.
- (h) Final report in preparation.

(3238) MODEL STUDY OF EUFAULA DAM, CANADIAN RIVER, OKLAHOMA.

- (b) District Engineer, U.S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Oklahoma.
 - (d) Experimental; for design.
 - (e) A 1:36 section model, reproducing two full bays and two flanking half bays of the 520-foot-long, gated spillway, the horizontal stilling basin, and approach and exit channels, was used to determine the adequacy of design of the stilling basin elements, and to investigate pressure conditions on the underdesigned spillway crest.
 - (f) Completed.
 - (g) Realinement of the upstream portion of the spillway crest resulted in improved pressure conditions for maximum head (39.7 feet); for design head (30.0 feet) pressures were about zero atmospheric. Model head-discharge relations agreed closely with computed values. Stilling basin tests resulted in a 33-foot decrease in apron length and permitted raising the apron 4 feet to about top of rock. Another modification made to obtain good basin performance at intermediate flows and prevent spray action at maximum flow was raising the baffle-pier height from 8 to 10 feet; the height of the end sill was maintained at 8 feet.
 - (h) "Eufaula Dam Spillway, Canadian River, Oklahoma; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-575, July 1961. (Available on loan.)
- (3239) MODEL STUDY OF SPILLWAY CREST GATE, STILLING BASIN, AND BULKHEAD, NEW CUMBERLAND LOCKS AND DAM, OHIO RIVER, PENNSYLVANIA.
- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
 - (d) Experimental; for design.
 - (e) A 1:25 section model reproducing 400 feet of the approach area, a portion of the gated spillway crest and stilling basin, and 500 feet of the exit area was used to examine the hydraulic performance of the spillway weir and stilling basin. A second phase of this study involved measurements of hydraulic forces acting on a submergible-type spillway tainter gate. A 1:25 model of a truss-type bulkhead with an upstream skin plate and lifting beam was used to determine the vertical forces acting on the bulkhead and lifting beam as they are lowered in flowing water. A 1:40 section model reproducing a 25-foot-wide section of the spillway and stilling basin was installed in a glass-sided flume which permitted observation of sub-surface basin action.
 - (f) Completed.
 - (g) The submergible gate was found to be stable for the complete range of operating conditions; computed hoist loads were verified. A stilling basin which is expected to provide excellent dissipation downstream from the nonsubmergible gates was developed. However, it was impracticable to modify prototype plans sufficiently to obtain good stilling action below the submergible gates for the full range of flow conditions. It is planned to avoid undesirable basin action by proper scheduling of gate operation. Bulkhead tests demonstrated the feasibility of the proposed method of emergency closure, and provided data on limiting conditions for satisfactory operation.
 - (h) "Spillway for New Cumberland Locks and Dam (Final Design), Ohio River, West Virginia; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-585, December 1961. (Available on loan.)
- (3241) STUDY OF SEICHE ACTION, DULUTH-SUPERIOR HARBOR, LAKE SUPERIOR.
- (b) District Engineer, U.S. Army Engineer District, St. Paul, Corps of Engineers,
- (d) Analytical; for design.
 - (e) Water-stage records obtained from gages in Duluth-Superior Harbor were analyzed to determine whether seiches are the cause of troublesome and damaging ship movements at loading docks in the harbor, and to provide information needed to design a hydraulic model, if the use of a model study is indicated.
 - (f) Analysis completed.
 - (h) Final report in preparation.
- (3242) MODEL STUDY OF CONNEAUT HARBOR, LAKE ERIE, OHIO.
- (b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.
 - (d) Experimental; for design.
 - (e) A 1:125 fixed-bed model was used to determine the influence of seiche currents and short-period wind-wave action in causing damage to ships navigating or berthed in Conneaut Harbor (located on the south shore of Lake Erie about 30 miles southwest of Erie, Pennsylvania), and to develop remedial plans. The model reproduced about 7.3 square miles including all the area within the harbor and sufficient adjacent lake area to permit reproduction of storm waves from all critical directions. A circulating system installed in the model permitted simulation of currents through and past the harbor caused by seiches on the lake.
 - (g) Results of the investigation show that (1) installing a shore connecting arm of breakwater between the present east breakwater and shore will not worsen currents inside the harbor and thus will permit proposed realinement of the east pier inside the harbor, and (2) a detached breakwater about 900 feet long located about 1,600 feet from the harbor entrance will provide adequate protection to the inner harbor from wave action.
 - (h) Final report in preparation.
- (3243) MODEL STUDY OF LOCKS AND DAM NO. 4, MONONGAHELA RIVER.
- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
 - (d) Experimental; for design.
 - (e) A 1:120 fixed-bed, comprehensive model, reproducing about 2.5 miles of the Monongahela River and the locks and dam structures was used to determine the effects of modifications to the existing locks and dam on navigation conditions, and to develop modifications required to overcome any undesirable conditions.
 - (f) Tests completed.
 - (g) Navigation conditions which can be expected with the existing locks and reconstructed dam without channel dredging were determined.
 - (h) Final report in preparation.
- (3244) MODEL STUDIES OF COLUMBIA LOCK AND DAM, CHATTAHOOCHEE RIVER.
- (b) District Engineer, U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama.
 - (d) Experimental; for design.
 - (e) A 1:100 fixed-bed type, comprehensive model, reproducing about 1.5 miles of the Chattahoochee River and the lock and dam structures was used to study the navigation conditions within the lock approaches and the head on lower lock gate during lock-emptying operations, and to develop modifications required to overcome any undesirable conditions found. Two section models were also used in the investigation to develop final spillway profiles and stilling basin dimensions: a 1:36 model of the fixed-crest spillway reproducing 250 feet of the approach

- area, a 36-foot-wide portion of the spillway and stilling basin, and 300 feet of the exit area; and a 1:27.2 model of the gated spillway reproducing 500 feet of the approach area, a portion of the spillway crest and stilling basin (one full gate bay and two half piers), and 500 feet of the exit area. Completed.
- (f) Tests of the spillway section models indicated that while the spillways performed satisfactorily, the stilling basins provided little or no energy dissipation. In the case of the gated spillway, flow passed over the spillway along the surface of the tailwater or dived over the stilling basin into the exit channel. With the fixed-crest spillway, flow normally does not begin until the tailwater over the basin is fairly deep. In such cases there was no measurable velocity at the spillway toe. Based on these observations, both basins were eliminated from prototype construction. Pressures on the gated spillway were positive for all conditions and instantaneous pressure fluctuations were negligible. Tests on the comprehensive model indicated that because of the location of the lock and dam with respect to the alignment of the channels, currents moving from along the left bank toward the dam would cross the upper approach to the lock, tending to make navigation conditions for downbound tows difficult. Conditions could be improved by modification of the excavation along the left bank, upstream extension of the guard wall or wing wall at the upper end of the guard wall; installation of ports in the upper guard wall; and installation of a training dike to deflect flow in the upper lock approach. No navigation difficulties are expected in the lower lock approach.
- (h) "Navigation Conditions, Columbia Lock and Dam, Chattahoochee River, Georgia and Alabama; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-571, July 1961.
- "Spillway and Stilling Basin, Columbia Dam, Chattahoochee River, Alabama and Georgia; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-578, October 1961. (Available on loan.)
- (3579) MODEL STUDY OF PIER SLIP SHOALING, NEW YORK HARBOR.
- (b) District Engineer, U.S. Army Engineer District, New York, Corps of Engineers, New York, New York.
- (d) Experimental; for design.
- (e) The study will be conducted in a section model reproducing that portion of the Hudson River between pier 21 (Duane Street) and West 158th Street, Manhattan, constructed to scales of 1:100 vertically and 1:300 horizontally, in which the tides, tidal currents, and shoaling of navigation slips will be reproduced. The purpose of the studies is to determine the causes of shoaling in the pier slips in New York Harbor and to develop plans for alleviating this shoaling.
- (f) Suspended.
- (g) Tests to date indicate that submerged sills or bubble screens across the entrances to certain slips would significantly reduce the rate of shoaling therein; however, the results of preliminary economic studies of these schemes indicate that neither would be economically feasible.
- (3581) MODEL STUDY OF LAKE PONTCHARTRAIN, LOUISIANA.
- (b) District Engineer, U.S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisiana.
- (d) Experimental; for design.
- (e) The investigation is being conducted in a fixed-bed model that reproduces to scales of 1:2,000 horizontally and 1:100 vertically, Mississippi Sound west of Grand Island, and Lakes Borgne, Pontchartrain, and Maurepas, together with significant tributaries. The model reproduces the tides, tidal currents, salinities, and fresh-water discharges of the prototype. The purpose of the study is to determine the effect of proposed hurricane-surge control structures across the connections between Lake Borgne and Lake Pontchartrain upon the hydraulic and salinity regimens of the area landward from the structures.
- (g) Test results indicate that the proposed gated control structures in the Rigolets and Chef Menteur Passes, which would reduce the existing cross-sectional area of the passes by about 75 percent, would have no significant effects on the present salinity regimen of the lakes.
- (3582) ARKANSAS RIVER CHANNEL MODEL.
- (b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
- (d) Experimental; for design.
- (e) The Arkansas River project has as one of its major aims the development of river navigation from the Mississippi River to the general area of Tulsa, Oklahoma. The Arkansas River channel model was of the movable-bed type with a horizontal scale of 1:150 and a vertical scale of 1:36, and reproduced the Arkansas River between miles 140.0 and 151.2. The model study constituted and idealized experimental approach to the solution of sedimentation problems involved in the canalization of the Arkansas River and was designed to investigate problems typical of and to provide results generally applicable to the various reaches of the over-all length of the river to be developed for navigation.
- (g) Tests provided general indications of the type of effects produced by the various regulative measures investigated, as follows: regulating structures which increase the radius of curvature of a bend over natural conditions provide a more uniform channel cross section and improve the alignment of the channel over the crossings; in bends, longitudinal dikes produce a more efficient channel than spur dikes, improve flow conditions and channel cross section, and reduce the amount and extent of shoaling in crossings; extending training works on a concave bank downstream into the crossing reduces shoaling in that crossing and improves flow conditions in the next bend downstream by reducing the tendency for a point bar to develop there; dredged spoil banks and willow growth on convex bars improve the alignment, depth, and shape of channel through the bend, and such spoil banks require only minor protection except at the upstream end; providing more contraction in the crossings than through the bends increases depths over the crossings and improve the channel alignment but also increases the water-surface slope at high flows; low-level spur groins in crossings to provide further contraction at low flows increase the depths over the crossings but produce considerable backwater and undesirable shoaling upstream; low-level longitudinal structures in crossings to provide further contraction at low flows are effective in fixing the location and alignment of the crossings and produce some lowering of controlling elevations over crossings but offer almost no resistance to the flow.
- (h) Preparation of final report in progress.
- (3583) MODEL STUDIES OF CARLYLE DAM, KASKASKIA RIVER, ILLINOIS.
- (b) District Engineer, U.S. Army Engineer District, St. Louis, Corps of Engineers, St. Louis, Missouri.
- (d) Experimental; for design.

- (e) Tests in a 1:36 comprehensive model, reproducing the spillway and allied structures, a portion of the earth embankment on each side of the spillway, and about 2,200 feet of approach and exit channel, were performed to: (1) Determine suitability of the excavation plan in the approach area and provide a means of studying alternate plans; (2) verify spillway capacity and provide data for use in the structural design; (3) study stilling basin performance and determine optimum design of basin training walls; and (4) provide information as a basis for developing a gate operating schedule.
- (f) Completed.
- (g) Extreme turbulence and excessive losses at the spillway abutments of the original design were corrected by addition of a spur dike at each abutment. Adequacy of the approach area excavation plan was verified. Data useful in the structural design of the spillway elements and information on which a gate operating schedule can be based were obtained. The feasibility of placing the stilling basin apron at the optimum elevation from a consideration of foundation conditions was verified. Addition of baffle piers to the apron was found desirable. Optimum top elevation for the basin training walls was determined.
- (h) "Carlyle Dam, Kaskaskia River, Illinois; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-568, June 1961. (Available on loan.)
- (3584) MODEL STUDIES OF RED ROCK DAM, DES MOINES RIVER, IOWA.
- (b) District Engineer, U. S. Army Engineer District, Rock Island, Corps of Engineers, Rock Island, Illinois.
- (d) Experimental; for design.
- (e) A 1:50 model that reproduced 900 feet of the approach channel above the spillway, an 825-foot-wide section along the dam, the spillway, conduits, stilling basin, and 575 feet of the outlet channel, and a 1:16 model that reproduced one conduit and a 16-foot-wide portion of the spillway and stilling basin were used to study flow conditions in the approach, particularly at the abutments, to verify stilling basin and training wall design, to evaluate reduction in conduit flow during combined operation, and to determine the need of armor plate at the outlet portal.
- (g) Tests on the 1:16 model indicated that during combined operation, simulating spillway and conduit flow at maximum reservoir elevation, pressures within the conduit and in the outlet portal were positive. "Eyebrows" or deflectors above the portal increased conduit flow and dropped the grade line within the conduit. A Folsom Dam high-level conduit, reproduced in the model, verified prototype cavitation-damage areas and furnished a basis for interpretation of Red Rock conduit test results.
- (h) Final report in preparation.
- (3585) MODEL STUDY OF NEW POE LOCK, ST. MARYS RIVER.
- (b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.
- (d) Experimental; for design.
- (e) A 1:25 preliminary culvert and single lateral model was used to test flow distribution within the lateral under various operating conditions. The major investigations were conducted in a 1:25 comprehensive model reproducing 1,000 feet of upstream approach, intake manifolds, the 1,000-foot lock chamber, culverts, bottom lateral outlet manifolds, and 500 feet of downstream approach. This model included provision for changing the arrangement of bottom laterals, lock length, culvert height, and culvert valve operating schedules, and was used to determine (1) adequacy of intake and discharge manifold designs, (2) maximum permissible lock filling and emptying rates with turbulence and hawser stresses within safe limits, and (3) best location, number, and spacing of bottom laterals. A 1:12 culvert valve model was used to study proposed valve design.
- (f) Completed.
- (g) The original design intake manifolds and upstream pier nose shape were revised to reduce vortex tendencies at the intake and improve flow distribution. The bottom split-lateral system (i.e. two groups of six laterals each) for filling and emptying the lock was satisfactory. The discharge manifold was revised to secure better flow distribution. The recommended single-speed 4-minute valve schedule for filling and single-speed 2-minute valve schedule for emptying the lock will result in maximum hawser stresses of 5 tons, filling time of 7.8 minutes, and emptying time of 7.3 minutes at normal 21-foot head. Data from the 1:12 model tests formed the basis for design of the filling and emptying valves.
- (h) "Filling and Emptying System, New Poe Lock, St. Marys River, Sault Ste. Marie, Michigan; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-561, April 1961. (Available on loan.)
- (3586) MODEL STUDY OF HOPPER DRAGHEAD.
- (b) District Engineer, U.S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pennsylvania.
- (d) Experimental; for design.
- (e) To develop improved dragheads designed to attain a greater rate of intake of solids when dredging mud and silt mixtures (soft materials) and dredging densely packed, fine sand (hard material), an investigation is being conducted in a 60- by 10-foot flume containing various types of bed material. The draghead and suction line, constructed to a scale of 1:6, are connected to a suction pump mounted on a double carriage that provides travel, both longitudinally and transversely, along the top of the flume.
- (f) Suspended.
- (g) Preliminary tests have indicated that the model draghead would tend to be more efficient in sand than the prototype because of modifications in the design and operation under more ideal conditions. Tests have also indicated that a mixture of available materials could be used to simulate prototype mud for the draghead test. Analysis of the data for sand has not progressed to a point where the significant design parameters for dragheads have been determined.
- (3587) MODEL STUDIES OF JOHN REDMOND DAM, GRAND RIVER, KANSAS.
- (b) District Engineer, U.S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Oklahoma.
- (d) Experimental; for design.
- (e) A 1:100 model that reproduced 2,900 feet of the approach channel above the spillway, the spillway, stilling basin, and 2,450 feet of the outlet channel, and a 1:36 model that reproduced one full bay and two half bays of the spillway and the stilling basin were used to study flow conditions in the shallow, curved spillway approach channel; to verify capacity of the structure and adequacy of the stilling basin and exit channel; and to determine minimum requirements for training walls.
- (h) Final report in preparation.
- (3588) MODEL STUDY OF SPILLWAY, BIG BEND RESERVOIR, MISSOURI RIVER, SOUTH DAKOTA.
- (b) District Engineer, U.S. Army Engineer

- District, Omaha, Corps of Engineers, Omaha, Nebraska.
- (d) Experimental; for design.
- (e) A 1:60 model, reproducing 2,400 feet of the approach channel, the spillway and stilling basin, and 1,000 feet of the exit channel, was used to determine: (1) velocity and flow characteristics in the approach channel; (2) spillway discharge rating data with emphasis on the effects of weir submergence; and (3) stilling basin behavior and exit channel velocity and scour data.
- (h) Final report in preparation.
- (3589) MODEL STUDY OF SPILLWAY, PIKE ISLAND DAM, OHIO RIVER, WEST VIRGINIA AND OHIO.
- (b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
- (d) Experimental; for design.
- (e) A 1:25 section model reproducing 300 feet of the approach area, a portion of the spillway crest and stilling basin, and 600 feet of the exit area was used to examine the hydraulic performance of the spillway and stilling basin.
- (f) Completed.
- (g) Tests of the original design stilling basin revealed that unsatisfactory basin action occurred at the larger gate openings (above a 6-foot opening). For satisfactory basin action, correct placement of the baffle piers in the basin below the spillway was essential. The most satisfactory basin consisted of a horizontal apron 67 feet long with a single row of 6-foot-high baffle piers located 42 feet below the spillway toe, and a 3-foot-high stepped end sill. Velocities in the exit did not exceed 6 feet per second for normal tailwater conditions.
- (h) "Spillway Stilling Basin for Pike Island Locks and Dam, Ohio River, Ohio and West Virginia; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-586, December 1961. (Available on loan.)
- (3590) MODEL STUDY OF WAVE ACTION, EAST PASSAGE, NARRAGANSETT BAY, RHODE ISLAND.
- (b) Division Engineer, U.S. Army Engineer Division, New England, Corps of Engineers, Waltham, Massachusetts.
- (d) Experimental; for design.
- (e) A 1:150 model is being used to determine the effects of tidal and hurricane surge currents, waves, and winds on the operation of an aircraft carrier in East Passage. A barrier across East Passage has been proposed to limit the quantity of water entering Narragansett Bay from hurricane surge, and the model study will examine ship navigation conditions with respect to barrier location and its navigation opening. A self-propelled, radio-controlled, model aircraft carrier, dynamically similar to its prototype, is being used in the tests.
- (g) Flume tests were conducted to determine the design of a barrier opening which would have the desired flow characteristics. Tests were completed to establish the current patterns and magnitudes which would affect navigation. Tests showed that an aircraft carrier can satisfactorily maneuver in all storm conditions up to and including the 1938 hurricane. Hurricane tide currents up to 12 knots, and spring astronomical tidal currents up to 5 knots can be expected if the barrier is constructed.
- (3592) MODEL STUDY OF TYPICAL NAVIGATION DAM, ARKANSAS RIVER.
- (b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
- (a) Experimental; for design.
- (e) The Arkansas river multipurpose project includes the development of river navigation from the Mississippi River to the general area of Tulsa. Present plans for navigation include construction of several navigation locks and dams. The purposes of the model study were to investigate various problems that occur in the vicinity of the structures. The investigation was conducted on a movable-bed model constructed to linear scales of 1:120 horizontally and 1:40 vertically, reproducing a 5-mile reach of a typical stream having characteristics generally similar to reaches of the Arkansas River, including a typical Arkansas River lock and dam structure.
- (h) Preparation of final report in progress.
- (3593) MODEL STUDY OF SPILLWAY, MAXWELL DAM, MONONGAHELA RIVER, PENNSYLVANIA.
- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
- (d) Experimental; for design.
- (e) A 1:25 section model reproducing 200 feet of the approach channel, a 25-foot-wide section of the gate, gate sill, and stilling basin, and 300 feet of the exit area was used to examine the hydraulic performance of the stilling basin. A second phase of the study consisted of determining the most efficient and economical stilling basin below Opekiska Dam, a structure similar to Maxwell. A sufficient range of tailwater conditions was tested to make the data applicable to both dams.
- (f) Completed.
- (g) Natural tailwater at Maxwell is adequate for formation of a hydraulic jump under assumed minimum conditions, and satisfactory performance was obtained in all five basin designs tested. Lowest bottom velocities resulted with a basin consisting of a 26-foot-long horizontal apron surmounted by a single row of 4-foot-high baffle piers and a 4-foot-high dentated end sill. At Opekiska natural tailwater is inadequate for formation of a hydraulic jump under assumed minimum conditions. A 16.8-foot-long horizontal apron terminated by a 4-foot-high dentated end sill will perform adequately with all four gates operating in 1-foot increments, and will result in acceptable maximum bottom velocities.
- (h) "Spillway Stilling Basins for Maxwell and Opekiska Locks and Dams, Monongahela River, Pennsylvania and West Virginia; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-579, October 1961. (Available on loan.)
- (3594) MODEL STUDY OF RIPRAP REQUIREMENTS FOR R.R. RELOCATION FILLS, ICE HARBOR DAM AND JOHN DAM PROJECTS, WASHINGTON AND OREGON.
- (b) District Engineer, U.S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
- (d) Experimental; for design.
- (e) Tests were conducted in a 5-foot-wide, 4-foot-deep, and 119-foot-long wave flume, using a linear scale of 1:12, model to prototype, to determine the stability of primary and secondary riprap, and gravel as cover-layer materials for protection of railroad relocation fills from wave action. The stability of the different types of cover-layer materials was determined as a function of depth below still-water level, slope of fill, depth of water, and wave period and height.
- (f) Completed.
- (g) The results of stability tests on three different gradations of primary riprap material are represented with very good accuracy by the formula $\gamma_r H^3$

$$W_{50} = \frac{K_{\Delta} (S_r - 1)^3 \cot \alpha}{\gamma_r H^3}$$

where W_{50} is weight of riprap (50 percent finer than), γ_r is the specific weight of riprap material, H is the height of selected design wave, S_p is the specific gravity of riprap relative to the fluid in which the structure is located (γ_r/γ_w), α is the angle of the fill slope, and K_A is a dimensionless coefficient. The weights of the underlayer material should be at least 1/20 of the weights of primary riprap.

(3596) HYDRAULIC STUDIES FOR IMPACT ENERGY DISSIPATOR DESIGN.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; applied research.
- (e) A general investigation to determine the energy loss coefficient of an impact energy dissipator of variable height and depth for varying slopes, diameters, and energy of flows of the upstream conduit will be conducted on a 1.0-foot-diameter impact energy dissipator. The energy of the influx will be determined from measurements of the discharge and the hydraulic gradient. The energy of the efflux will be determined from measurements of the discharge from each of four quadrants. The slope and size of the incoming pipe will be varied to determine the effect of each upon the energy dissipated. For a particular slope and diameter of the incoming pipe and a particular height and depth of the dissipator, the relative energy content of the efflux to the influx will be determined for as great a range of Reynolds numbers as possible to ascertain the effect of Reynolds number upon the energy loss in the dissipator.

(3597) CORRUGATED PIPE ROUGHNESS STUDY.

- (b) Office of the Chief of Engineers, Department of the Army, and Bureau of Public Roads, Department of Commerce, Washington, D.C.
- (d) Experimental; applied research.
- (e) This is a general investigation to determine a resistance coefficient and the law of velocity distribution for flow in structural-plate corrugated pipe. A fiber-glass test section reproducing a 5-foot-diameter standard corrugated pipe at a scale of 1:4 was tested in order to obtain additional data on the resistance coefficient and velocity distribution and to correlate model work with full-scale tests. Fiber-glass test sections reproducing a 5-foot-, 10-foot-, and 20-foot-diameter structural-plate pipe at scales of 1:2.2, 1:8, and 1:16, respectively, will be tested to determine the effect of relative roughness upon the resistance coefficient and velocity distribution. The hydraulic gradient and the energy loss through 20- to 80-diameter lengths of test section will be established by piezometers located at 5-foot intervals. These piezometers will be 1/8 inch in diameter, on center of the crests of the corrugations, and four in number around the periphery of the pipe. Velocity traverses will be made by means of calibrated pitot tubes at several locations along the test section for determination of the velocity distribution.
- (g) Tests conducted on the model reproducing standard corrugations at a scale of 1:4 have been completed and the results for a range of Reynolds numbers from 4×10^4 to 2×10^5 agree favorably with results of full-scale studies made at Bonneville Hydraulic Laboratory. Results of tests on the models simulating 5-foot-, 10-foot-, and 20-foot-diameter structural-plate pipes indicate maximum Manning's "n" of 0.032, 0.030, and 0.027, respectively. At present additional high- and low-velocity tests are being conducted in the models simulating the 10-foot- and 5-foot-diameter structural-plate pipes, respectively, to obtain velocity distribution data in an overlapping range of wall Reynolds

number.

(3598) MODEL STUDIES OF CONTAMINATION DISPERSION IN ESTUARIES.

- (b) Nuclear Projects Office, Maritime Administration, U.S. Department of Commerce.
- (d) Experimental; applied research.
- (e) The increasing use of nuclear reactors in the production of automotive power, both on land and sea, presents new problems pertaining to the dispersal of radioactive waste released either accidentally or purposely into rivers, estuaries, and harbors. The Maritime Administration is concerned with the probable dispersion patterns of radioactive matter that might be released in accidents involving nuclear-powered ships. A series of tests was made on several existing models of important estuaries, including the Delaware River, Narragansett Bay, New York Harbor, and San Francisco Bay, in order to obtain data from which dispersion effects could be computed. Tides, tidal currents, salinities, and fresh-water flow were reproduced for all tests. Methylene blue chloride dye was used to simulate contamination, and the dye releases were generally made at the most adverse time of tide in relation to the potential upstream spread of the contaminant. Water samples were obtained periodically throughout the contaminated area for spectrophotometer analysis, and in addition, meters which automatically measured and recorded dye concentrations were in continuous operation at strategic locations. Results obtained are expressed as percentages of the initial concentration.
- (g) Tests in the San Francisco Bay model have been completed, and the results are being analyzed by the Waterways Experiment Station. The report thereon will contain descriptions of test procedures and techniques, and tables and plates presenting the data obtained. Analyses of data from all model tests will be made and conclusions drawn by Dr. D.W. Pritchard of Johns Hopkins Univ.

(3902) RADIOACTIVE TRACER TESTS OF SEDIMENT, GALVESTON BAY, TEXAS.

- (b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.
- (d) Experimental; field investigation.
- (e) The movement of sediment in the vicinity of the Galveston Bay Jetty was investigated by use of radioactive gold-impregnated glass. The glass was ground to the particle size of the natural sediment and was deposited at three locations on the north side of the jetty. The paths of the activated, gold-impregnated glass particles were traced by instruments from a small boat. Readings were procured over a period of about one week. It was expected that the tidal action, littoral current, and wind waves would move the material around the end of the jetty and/or through the jetty.
- (f) Tests completed.
- (g) Most of the radioactive material passed through a small boat opening in the jetty. Further tests are necessary to determine whether any material passes around the end of the jetty.
- (h) Final report in preparation.

(3903) MODEL STUDY OF WAVE ACTION, HILO HARBOR, HAWAII.

- (b) District Engineer, U.S. Army Engineer District, Honolulu, Corps of Engineers, Honolulu, Hawaii.
- (d) Experimental; for design.
- (e) A fixed-bed hydraulic model is proposed to determine the optimum breakwater plan to decrease wave and surge action in Hilo Harbor so that troublesome and damaging ship motion at piers 1, 2, and 3 will be alleviated. To

date, prototype instruments to measure wave and surge action at piers 1 and 2 have been obtained with which measurements will be made for use in determining the cause of the problem and in design of the model. This model will also be used to investigate the effects of different plans of construction on the reduction of damage to the city of Hilo from tsunamis.

(g) Design of model is in progress.

(3904) MODEL STUDY OF DESIGN OF RUBBLE-MOUND BREAKWATER, MORRO BAY, CALIFORNIA.

(b) District Engineer, U.S. Army Engineer District, Los Angeles, Corps of Engineers, Los Angeles, California.

(d) Experimental; for design.

(e) Stability tests were conducted in a concrete wave flume 119 feet long, 5 feet wide, and 4 feet deep, in which a section model of the Morro Bay Harbor breakwater had been constructed to a linear scale of 1:53.7. The study was performed to obtain data from which alternate designs could be developed for repair of the damaged breakwater. Design criteria for both the head and trunk of the structure were desired. Proposed designs involved cover layers of either quarystone, tetrapod, tribar, or pelican-stool armor units.

(f) Completed.

(g) It was found that a considerable portion of the breakwater trunk would be stable under attack of waves 24 feet high (design-wave height) if the lower layer was composed of quarystones weighing 10 to 20 tons placed on a slope of 1 on 2-1/2. Another reach of the structure could be constructed of quarystones weighing 10 to 30 tons placed on a slope of 1 on 1-3/4. Design of the breakwater head was difficult. However, it was determined that the head should be composed of concrete armor units of special shape, weighing 20 tons, with slopes varying from 1 on 1-1/2 on the seaside to 1 on 3 on the harbor-side.

(h) "Designs for Rubble-Mound Breakwater Repair, Morro Bay Harbor, California; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-567, May 1961. (Available on loan.)

(3905) KELLEYS ISLAND HARBOR STUDY, LAKE ERIE, OHIO.

(b) Ohio State.

(d) Analytical; for design.

(e) An analytical study was conducted to determine the characteristics of short-period wind waves which occur at the site of the proposed Kelleys Island harbor of refuge. Deep-water waves were charted into the position of the harbor entrance by use of refraction diagrams. The resulting data were used to determine the optimum alignment of the navigation opening, and the need for, and approximate length of a protecting breakwater.

(f) Study completed.

(g) Results of the combined refraction-diffraction analysis show that a breakwater extending 900 feet northwesterly from shore, out to -10 feet low-water datum, and a companion breakwater about 400 feet long, with an entrance channel approximately 150 feet wide will provide adequate protection to the inner harbor from wave action.

(h) Final report in preparation.

(3906) POWER PLANT TRANSIENTS TESTS, GARRISON AND CAHE DAMS, MISSOURI RIVER, NORTH DAKOTA.

(b) Division Engineer, U.S. Army Engineer Division, Missouri River, and District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.

(d) Field investigations; applied research and design.

(e) Hydraulic prototype measurements of power plant transients at Garrison Dam have been

made to evaluate results of a comprehensive digital computer study made by the sponsoring offices, and to determine extent operation corresponds with design in order to develop a solution of the entire problem of power plant transients, with primary emphasis on governing stability. For different plant loadings, instantaneous pressure valves at a number of locations in the power tunnel, the surge tank system, turbine scroll case, and draft tube were obtained simultaneously with instantaneous values of tunnel velocity, reservoir and tailwater elevations, turbine speed and gate opening, power output and other elements (including governor system). Pressure and water-level measurements were made with electrical pressure transducers, velocities with pressure transducers mounted in probes projecting into the flow, and mechanical and electrical valves with appropriate transducers. Measurements were recorded on about 90 channels of oscillograph and magnetic tape recorders. Data from the Garrison tests are being digitized for computer analyses. Tests at Cahe Dam probably will be made in the spring of 1963.

(3907) SHOALING PROCESSES.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

(d) Experimental; for design.

(e) The annual cost to the Federal Government of maintaining navigable channels in tidal waterways is estimated to be of the order of \$60,000,000. The Corps of Engineers Committee on Tidal Hydraulics has concluded that a thorough study of shoaling processes in tidal waterways would lead to improvements in channel design, dredging, and spoiling practices, and other maintenance techniques which would reduce this large expenditure. The Committee concludes that the following program of research is essential in arriving at the objective of reducing maintenance cost: (1) Flume studies to determine the basic laws involved in the movement and deposition of muddy sediments; (2) flume studies to determine effects of repetitive scour and deposition on sedimentation; (3) the development of techniques for using radioactive tracers for observing the movement and deposition of sediments in nature; (4) the development of a simple and accurate instrument for in-place measurement of turbidity; (5) a study of the physical, chemical, and hydraulic factors involved in the stabilization of deposits in navigable channels; (6) determination of the effects of flocculation on shoaling; (7) prototype studies aimed at correlation of sedimentation phenomena in tidal waterways with physical, chemical, hydraulic, salinity, and other significant factors; and (8) classification of the sediments which constitute all major repetitive shoals in tidal waterways. Item (1) is being conducted under contract by the University of California. A literature survey of items (5) and (6) was conducted by the Waterways Experiment Station. Items (3) and (4) are being conducted by other agencies at no cost to the Federal Government. Item (2) is inactive.

(3908) ARKANSAS RIVER NAVIGATION MODEL.

(b) District Engineer, U.S. Army Engineer District, Vicksburg, Corps of Engineers, Vicksburg, Mississippi.

(d) Experimental; for design.

(e) A fixed-bed model reproducing to scale of 1:600 horizontally and 1:100 vertically about 33 miles of the Mississippi River near the mouths of the White and Arkansas Rivers, 57 miles of the lower Arkansas River, 12 miles of the lower White River, and the major portion of the White-Arkansas River backwater area was used for investigation. The model was used to demonstrate alternate routes for

- the entrance to the Arkansas River navigation project, flow patterns, nature of overbank flow, effect of Arkansas-White Cutoff, and problems related to the location and alignment of the navigation entrance to the Arkansas River from the Mississippi River.
- (h) Final report in preparation.
- (3909) MODEL STUDY OF OPOSSUM CREEK LOCKS AND DAM, OHIO RIVER.
- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
- (d) Experimental; for design.
- (e) A 1:120, fixed-bed comprehensive model reproducing about 4 miles of the Ohio River and the lock and dam structures was used to study navigation conditions in the approaches to the locks, determine suitability of the selected site, and develop modifications required to overcome any undesirable conditions found.
- (f) Suspended.
- (3911) MODEL STUDY OF MATAGORDA SHIP CHANNEL, TEXAS.
- (b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.
- (d) Experimental; for design.
- (e) The fixed-bed model, constructed to scale ratios of 1:1,000 horizontally and 1:100 vertically, reproduces about 800 square miles of prototype area, including all of Matagorda Bay, part of the connecting bay system, and a portion of the Gulf of Mexico adjacent to Pass Cavallo. Tides and tidal currents are reproduced by one primary tide generator and one secondary tide generator, and fresh-water discharges of tributaries, together with the rainfall over the area, are introduced by means of weirs and flowmeters. Salt water is used in the model gulf to reproduce the prototype salinity regimen and provisions have been made for the injection of silt in the model for measurements of deposits on the bed of the model. Studies will be made to determine: (1) The best location for the entrance channel; (2) the best route for the channel from the entrance to Point Comfort; (3) such protective works as may be required in the interests of navigation and maintenance of the channel; and (4) the effects of the deep-draft navigation channel on the salinity regimen of the bay system.
- (g) Test results indicate that one of the proposed channel routes is superior to any of the other channel routes tested.
- (3912) MODEL STUDY OF GALVESTON BAY, TEXAS.
- (b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.
- (d) Experimental; for design.
- (e) A movable-bed model, with scale ratios of 1:500 horizontally and 1:100 vertically, will reproduce about 174.5 square miles of prototype area, including a small portion of Galveston Bay and a portion of the Gulf of Mexico extending 8 miles north of the north jetty, 6-1/2 miles south of the south jetty, and offshore to about the 50-foot contour of depth. Tides, tidal currents, littoral currents, and wave action in the Gulf of Mexico will be reproduced. Studies will be made to determine: (1) Plans for relocation and stabilization of the jetty channel on an alignment and depth suitable for navigation of supertankers; (2) means of protecting the north jetty from undermining action of tidal currents; (3) shoaling characteristics of the relocated and deepened jetty (inner bar) channel and plans for minimizing shoaling; and (4) shoaling characteristics of the deepened outer bar channel. Hydraulic verification of the model has been completed, and the movable-bed verification is in progress.
- (3913) MODEL STUDY OF GULF OUTLET CHANNEL, LOUISIANA.
- (b) District Engineer, U.S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisiana.
- (d) Experimental; for design.
- (e) The investigation is being conducted in a fixed-bed extension of the Lake Pontchartrain model and in conjunction with that model study. Reproduced is that area eastward of New Orleans to Breton Sound and south of Lakes Pontchartrain and Borgne to include the connecting waterways between those lakes and the Gulf Outlet Channel, now under construction. Scales are 1:2,000 horizontal and 1:100 vertical. Tides, tidal currents, salinities, and water exchange through the connecting waterways are simulated. Purpose of the study is to determine the effect of the channel on the salinity regimens of Lakes Pontchartrain and Borgne, which will be connected to the channel by existing waterways.
- (f) Study completed.
- (g) A preliminary analysis of the test results indicates that the Gulf Outlet Channel, with no control over its connection to Lake Pontchartrain through the Industrial Canal, would cause a large increase in the present salinity of the lake. The tests also showed that a control structure could be installed in the Industrial Canal and could be operated effectively to control the salinity of the lake at any level between that existing at present and the higher level that would exist without such a control structure.
- (h) Report in preparation.
- (3914) MODEL STUDY FOR MODERNIZATION OF EXISTING LOCK, McALPINE LOCKS, OHIO RIVER.
- (b) District Engineer, U.S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
- (d) Experimental; for design.
- (e) A 1:25 model which reproduced the filling and emptying system was used to develop feasible modifications which will improve prototype performance.
- (f) Completed.
- (g) Tests established the need for connecting the filling and emptying culverts and determined the best port arrangement and valve schedule for filling the locks. Tests indicated that the best port arrangements still will not permit filling in less than 16 minutes if requirement for a maximum hawser stress of 5 tons is satisfied. A filling time of 16 minutes with approximately equal hawser stresses can be obtained, either by use of the type 2 intake and a 12-minute valve schedule or the type 1 intake and a 4-minute valve schedule. If maximum hawser stresses greater than 5 tons are allowed, advantages can be gained by use of the type 2 intake.
- (h) Final report in preparation.
- (3915) MODEL STUDY OF DROP STRUCTURE, GERING VALLEY PROJECT, GERING VALLEY, NEBRASKA.
- (b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
- (d) Experimental; for design.
- (e) A 1:12 model reproducing successively three typical drop structures, adjacent overbank areas, and 300 feet of the approach and exit areas will be used to examine the hydraulic performance of the drop structures, which will vary in width from 6 to 33 feet and have drop heights of 5 and 10 feet.
- (g) Families of curves have been developed to permit selection of drop structure design based on drop and discharge conditions.
- (3916) MODEL STUDY OF OAHE RESERVOIR SPILLWAY, MISSOURI RIVER, SOUTH DAKOTA.

- (b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha Nebraska.
- (d) Experimental; for design.
- (e) A 1:50 model reproduced the remote, gated control structure which will serve as spillway along with approximately 3,000 feet of approach and exit channel. The model study was intended to: (1) Indicate head losses through structure and in channel, and provide data on flow patterns and velocities; (2) verify discharge data for gate bays; and (3) develop design of stilling basin, and of transition from stilling basin to sloped sides of exit channel.
- (f) Tests completed.
- (g) As a result of the model tests the exit channel was redesigned so that the concrete transition walls from basin to exit channel were moved upstream 50 feet and all baffling elements were removed from the basin. A gate schedule of operation was developed to prevent bottom velocities in the exit from exceeding 15 feet per second, and the required length of concrete apron below the structure was determined. No changes were required in the approach channel or to the spillway crest.
- (h) Final report in preparation.
- (3917) GENERAL SPILLWAY MODEL TESTS.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
- (d) Experimental; for design.
- (e) Tests are made on various elements of spillways to develop improved designs and to better define values of coefficients used in design formulas. A series of tests is being conducted on low weirs to determine optimum shape from a consideration of discharge coefficients and pressures.
- (3918) MODEL TESTS FOR TYPICAL FLOOD- AND WATER-CONTROL STRUCTURE.
- (b) District Engineer, U.S. Army Engineer District, Jacksonville, Corps of Engineers, Jacksonville, Florida.
- (d) Experimental; for design.
- (e) A 1:16 model, reproducing 384 feet of the approach channel, an 81.35-foot-wide 3-bay structure, the spillway, stilling basin, and 192 feet of the outlet channel, was used to determine the discharge coefficient and flow conditions of similar project structures having various approach and exit channel elevations for both controlled and uncontrolled flows.
- (f) Tests completed.
- (g) As expected, results indicate that the greater the depth of approach and/or difference in elevation between weir crest and exit channel, the greater the discharge coefficient for all flow conditions. Expressions describing free and submerged controlled and uncontrolled flow conditions have been determined. Present data analyses are concerned with determining parameters that will define the limits of each of the four possible flow conditions.
- (h) Final report in preparation.
- (3919) MODEL STUDY OF ALLEGHENY DAM, ALLEGHENY RIVER, PENNSYLVANIA.
- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
- (d) Experimental; for design.
- (e) A 1:36 model reproduced a 375-foot-wide section of the approach, the entire spillway and portions of each abutment, the six low-level sluices and two high-level sluices, the stilling basin, and a 425-foot-wide section of the exit channel. The model provided a means for determining sluice design, spray wall heights, and stilling basin design. Weir calibration data and pressures were determined.
- (g) Model tests verified hydraulic performance of the weir (as there was close agreement between model and computed weir rating curves), facilitated selection of types of high-level and low-level sluice designs, and refined design of the stilling basin by raising the apron elevation 3 feet and decreasing the height of the barrier piers 3 feet.
- (h) Final report in preparation.
- (4382) HYDRAULIC PROTOTYPE TESTS.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Field investigations for applied research and design.
- (e) The hydraulic prototype testing program of the Corps of Engineers is coordinated for complete coverage of needed testing, prevention of unnecessary duplication of testing facilities and tests, recommendations of installations at projects where physical and hydraulic conditions will be suitable for obtaining data, and investigation of prototype hydraulic performance. Personnel and equipment are made available to Corps of Engineers Districts conducting hydraulic field tests. Assistance also is given in planning test facilities, analyzing data, and preparing reports.
- (g) Prototype measurements were made of average and fluctuating pressures on the Table Rock Dam spillway crest for several gate openings. Velocity and pressure data obtained in a 22-foot-diameter tunnel at Fort Randall Dam were analyzed. (See also report on McAlpine Lock emergency gate, item 3906 on power plant transients tests, and item 2925 on ultrasonic flow measurement.)
- (4383) MODEL STUDY OF TURTLE CREEK CHANNEL IMPROVEMENT, PENNSYLVANIA.
- (b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
- (d) Experimental; for design.
- (e) To evaluate proposed channel improvements and determine the necessity for raising bridges and modifying piers and abutments, a 1:50 model reproducing the lower 7,000 feet of Turtle Creek channel was used. The model included provisions for testing plans with the existing and improved channels in the lower, 1,500-foot reach of the channel.
- (f) Tests completed.
- (g) Results of tests with the original design checked computed water-surface profiles closely. Various improvement plans involving channel realignment and modification to bridges and piers were tested which resulted in additional lowering of the water-surface profile through the channel.
- (h) Report in preparation.
- (4384) MODEL STUDY OF SPILLWAY, PROCTOR RESERVOIR, LEON RIVER, TEXAS.
- (b) District Engineer, U.S. Army Engineer District, Fort Worth, Corps of Engineers, Fort Worth, Texas.
- (d) Experimental; for design.
- (e) A 1:40 model reproducing a center bay and adjacent half bays of the spillway and stilling basin, and 400 feet of approach and exit areas, was used to verify the weir coefficients by means of head-discharge relations and pressure measurements on the spillway, and to determine the effect of varying the depth of approach and the slope of the upstream weir face on these conditions. Results will be used for other projects with similar weir shapes.
- (f) Tests completed.
- (g) Decreasing depth of approach increased weir coefficients slightly; however, pier contraction coefficients were also increased.

- Making crest shape tangent to upstream face of weir increased weir coefficients.
- (h) Final report in preparation.
- (4385) MODEL STUDY OF BELLEVILLE LOCKS AND DAM, OHIO RIVER, OHIO AND WEST VIRGINIA.
- (b) District Engineer, U.S. Army Engineer District, Huntington, Corps of Engineers, Huntington, West Virginia.
- (d) Experimental; for design.
- (e) The project involves construction of a nonnavigable-type dam with parallel locks; the main lock will be 1,200 feet by 110 feet and the auxiliary lock 600 feet by 110 feet. A 1:120 fixed-bed model reproducing about 3 miles of the river is being used to study navigation conditions in the lock approaches and the effects of the structures on flood stages.
- (g) With the original design, currents above the locks would move generally parallel to the right bank and approach the guard wall at an angle to the wall. Because of the high current velocities, drifting downbound tows would tend to approach the guard wall at relatively high speeds unless their forward movement were retarded. Tows would also encounter some difficulty in pulling away from the guard wall and in approaching the guide wall for passage through the auxiliary locks. No serious navigation difficulties are indicated in the lower approach to the locks.
- (4386) MODEL STUDY OF HOLT LOCK AND DAM, WARRIOR RIVER, ALABAMA.
- (b) District Engineer, U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama.
- (d) Experimental; for design.
- (e) A 1:80 model, reproducing the structures, 4,800 feet of the approach channel and 4,800 feet of the exit channel, was used to study flow conditions in the lock approaches and in the approach and exit channels for all arrangements of the structures. A 1:36 section model reproducing one full bay and two adjacent half bays of the spillway and stilling basin was utilized for studies of the adequacy of the weir and stilling basin design. A 1:25 model reproducing 800 feet of the lock approach channel, intake manifolds, the 670-foot lock chamber, culverts, bottom laterals, outlet stilling basin, and 730 feet of the downstream exit channel was used to study various types of filling and emptying systems to determine the most advantageous system from the standpoints of rate of operations, degree of turbulence, and economy. A 1:15 model of a culvert valve was used to study proposed valve designs.
- (g) From tests made to date, results from the 1:80 general model indicate that the overall arrangement and location of the structures are generally satisfactory. Installation of a 300-foot-long dike in the downstream river channel offered some improvement in flow conditions in the lower approach to the lock. Tests on the 1:36 section model indicate that the 80-foot-long apron-type basin can be replaced with a small 20-foot-radius bucket. In the 1:25 lock model the original design laterals were revised for better flow distribution between the 12 ports. The bottom middle-third lateral system was found to be feasible, and it is anticipated that increasing the spacing between the laterals in this system will further improve performance of this system. Data from the 1:15 valve model will form the basis for design of the filling and emptying valves.
- (4387) MODEL STUDY OF WILLOW SPRINGS AND SAG JUNCTION DIVERSIONS, CHICAGO SANITARY AND SHIP CANAL, ILLINOIS.
- (b) Metropolitan Sanitary District of Greater Chicago, Chicago, Illinois.
- (d) Experimental; for design.
- (e) Tests are being conducted on two 1:60 models, which reproduce the diversion channels and a portion of the Sanitary and Ship Canal at each location, to determine the effect of crosscurrents on navigation and to verify or further develop the hydraulic design of the diversion channels and appurtenant hydraulic structures. A 1:16 section model is being used for study of the control structures.
- (g) Strong crosscurrents in the canal adjacent to the Willow Springs diversion were improved by adjusting the heights of the curtain walls in the bridge bays to obtain equal distribution of flow through the bridge. Design capacity of the Willow Springs diversion can be met with only seven gate bays while ten are provided. Satisfactory flow distribution obtained through the diversion bridge and control structure at Sag Junction as well as satisfactory navigation conditions in the Sanitary Canal. Operation data are being obtained for a full range of hydraulic conditions on both diversion studies. Study of single gate hydraulic conditions and stilling basin action below the control gates is being completed in the section model.
- (4388) SECTION MODEL STUDY OF LOCK AND DAM NO. 6, ARKANSAS RIVER, ARKANSAS.
- (b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
- (d) Experimental; for design.
- (e) A 1:25 section model, reproducing a 5-foot depth of approach channel, one 60-foot gate bay and two adjacent half bays, the spillway stilling basin, and outlet channel, is being used to determine the optimum parabolic shape of the downstream face of the gate sill, the dimensions and elevation of the stilling basin, the shape of the gate piers, the spillway rating curves with full and partially opened gates, and the minimum riprap requirements for various elevations of the exit channel.
- (g) Tests regarding shape of the gate piers indicated that either the semicircular or ogival pier nose was satisfactory; however, the ogival pier nose yielded a slightly greater value of the discharge coefficient. Tests on the parabolic gate sill shape based on the trajectory of a free jet showed that a parabola based on a 10-foot head rather than the original 24-foot head would result in desirable basin action under all expected conditions. This allows a 13.5-foot reduction in length of gate sill.
- (4389) MODEL STUDY OF WAVE ACTION, LORAIN HARBOR, OHIO.
- (b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.
- (d) Experimental; for design.
- (e) A 1:125 fixed-bed is being used to determine the influence of storm wave action and attendant currents in causing navigation hazards at Lorain Harbor which is located at the mouth of Black River on the south shore of Lake Erie. The model reproduces about 8.8 square miles including all the area within the harbor and sufficient adjacent lake area to permit reproduction of waves from all critical directions. Waves are generated in the model by a 60-foot-long plunger-type wave machine and wave heights are measured electrically by an oscillograph.
- (g) It has been determined that the proposed detached breakwater plan will not cause more adverse currents at the entrance channel. Tests are in progress to determine whether a breakwater plan can be developed that will provide sufficient protection at less cost.

- (4390) MODEL STUDY OF CANNELTON LOCKS AND DAM, OHIO RIVER, INDIANA AND KENTUCKY.
- (b) District Engineer, U.S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
 - (d) Experimental; for design.
 - (e) The project involves the construction of a nonnavigable dam with parallel locks, the main lock to have clear dimensions of 1200 by 110 feet and an auxiliary lock, 600 by 110 feet. A 1:120 model reproducing about 9 miles of the river will be used for investigation of navigation conditions in the lock approaches, effects of the structures on flood stages, to obtain data for development of rating curves, and to determine the effect of powerhouse installation on flow and navigation conditions.
- (4391) MODEL STUDY OF LOCK AND DAM NO. 3, ARKANSAS RIVER, ARKANSAS.
- (b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
 - (d) Experimental; for design.
 - (e) A movable-bed model reproducing about 13 miles of the Arkansas River and adjacent overbank area, constructed to a scale of 1 to 120 horizontally and 1 to 80 vertically, will be used to determine the suitability of the proposed site for the lock and dam structure, the effects of proposed regulating works in the vicinity including a cutoff, and modification which might be required to provide adequate channel depths in the lock approaches and safe navigation conditions with minimum maintenance.
- (4392) EXTENSION OF LA GUARDIA FIELD RUNWAY, NEW YORK.
- (b) Port of New York Authority.
 - (d) Experimental; for design.
 - (e) The existing New York Harbor model is being used for tests to determine the effects of certain proposed fills in East River, for the purpose of extending the North-South runway at La Guardia Airport, on the hydraulic and flushing characteristics of the surrounding areas. Tests results are being analyzed by the Port of New York Authority.
 - (f) Tests completed.
 - (h) Report in preparation.
- (4393) MODEL STUDY OF STABILITY OF SOUTH JETTY, SIUSLAW RIVER, OREGON.
- (b) District Engineer, U.S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
 - (d) Experimental; for design.
 - (e) Stability tests were conducted in two wave flumes 119 feet long, 5 feet deep, and 4 feet wide on section models of the jetty constructed to a linear scale of 1:50 to determine experimental coefficients (K_A) in the Waterways Experiment Station breakwater stability equation for design of repairs of the south jetty at the river mouth. Design criteria were also desired for both the head and trunk of the structure for the conditions of (1) waves breaking directly on the structure, (2) special placement by crane of selected long-axis stones above low tide, (3) angles of wave attack of 0 and 90 degrees, and (4) pell-mell placement by crane of cover-layer stones from toe of jetty to crest.
 - (f) Tests completed.
 - (g) It was found that values of K_A vary only slightly with the angle of wave attack. Also, it was found that the stability of the jetties could be improved by placing long-axis stones so that the long axes were normal to the breakwater slope. Design coefficients were determined for the jetty head and trunk sections situated in water depths of 14, 21, 30, and 40 feet.
- (h) Report in preparation.
- (4394) MODEL STUDY OF CIRCULATION CURRENTS IN LAKE MICHIGAN.
- (b) U.S. Public Health Department.
 - (d) Experimental; for design.
 - (e) The water quality of Lake Michigan is determined primarily by the quantities, concentrations, and locations of waste material introduced into the lake, and the circulation patterns of the water masses of the lake. Thus, the U.S. Public Health Department desires to develop a comprehensive plan to control and prevent pollution in the lake by means of hydraulic model investigation which will provide detailed information on the distribution and concentration of pollutants. It is tentatively planned that the model will reproduce the forces of the earth's rotation, shear of wind on the water surface, density differences in the lake water, and inflows and outflows of water in the lake.
 - (g) A literature survey has been conducted and it is believed that (1) it is feasible to conduct a comprehensive model investigation of the circulation currents in Lake Michigan, (2) the model should be about 150 feet in diameter, and (3) a pilot model about 15 feet in diameter should be constructed and operated before design of the large model is undertaken.
- (4395) DISPERSION STUDIES IN NEW YORK HARBOR MODEL.
- (b) Interstate Sanitation Committee.
 - (d) Experimental; for design.
 - (e) The existing New York model is being used for a comprehensive study of the diffusion patterns from most of the major sewer outfalls in New York Harbor. Model tests are conducted using conservative fluorescent dyes as tracers, and the results will be used for planning the construction of additional sewage treatment facilities. Results are being analyzed by the Interstate Sanitation Commission.
- (4396) MODEL STUDY OF COLUMBIA RIVER, OREGON AND WASHINGTON.
- (b) District Engineer, U.S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
 - (d) Experimental; for design.
 - (e) The model will reproduce the lower 52 miles of the Columbia River and pertinent offshore areas to linear scales of 1:500 horizontally and 1:100 vertically. Tides and tidal currents, density currents, waves, and other phenomena significant to the movement and deposition of sediments will be reproduced and studied. Some portions of the model will be of the fixed-bed type, while other portions will be of the movable-bed type. Design and construction of the model are in progress.
- (4397) McALPINE LOCKS EMERGENCY GATE PROTOTYPE TESTS.
- (b) District Engineer, U.S. Army Engineer Dist., Louisville, Corps of Engrs., Louisville, Ky.
 - (d) Experimental; for design.
 - (e) Prototype measurements of the forces acting on the downstream leaf of a two-leaf, vertical-lift emergency gate were made to determine acceptability of the gate under flowing water conditions. Measurements included tension in the dead end of the hoist fall lines, gate-end elevations and gate vibration. The prototype downpull and gate vibration will be compared with the result of a model study of a similar installation (1738).
 - (g) Tests completed; data being analyzed.
- (4398) MODEL STUDY OF AMISTAD DAM SPILLWAY, RIO GRANDE.
- (b) District Engineer, U.S. Army Engineer

- District, Fort Worth, Corps of Engineers, Fort Worth, Texas.
- (d) Experimental; for design.
- (e) A 1:70 model reproducing one-half of the river for a distance of 1,500 feet upstream and 2,500 feet downstream, one powerhouse, and one-half of the 975-foot-wide, 16-bay structure including the spillway and stilling basin is being used to determine spillway rating curves, flow conditions at the abutments and training walls, pressures on weir crest, lateral pressures on pier subjected to unbalanced flow, and stilling basin action. A 1:20 section model reproducing two of the irrigation conduits and the portion of the stilling basin into which they discharge, one powerhouse and tailrace, and about 500 feet of exit channel is being used to investigate the adequacy of the stilling basin for releases from the conduits and the flow conditions in the power tail-race.
- (4399) MODEL STUDY OF STABILITY OF BREAKWATER, TSOYING HARBOR, TAIWAN.
- (b) District Engineer, U.S. Army Engineer District, Okinawa, Corps of Engineers, San Francisco, California.
- (d) Experimental; for design.
- (e) Stability tests are being conducted in a concrete wave flume 119 feet long, 12.5 feet wide, and 4 feet deep on section models of the breakwater constructed to a linear scale of 1:47.6 to obtain data from which alternate designs can be developed for construction of the proposed breakwater. Design criteria for both the head and trunk of the breakwater are desired. Cover layers of both quarystone and quadripod armor units are being tested.
- (g) Preliminary analysis of test results indicate that head and trunk sections of the breakwater constructed of 25- to 35-ton quarystones would be stable for waves 27 feet in height. For these conditions the slope of the head section would be 1:4.5, and the slope for the trunk section would be 1:3.5.
- U. S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS.
- (3700) UNSTEADY FLOW IN STORM DRAINS, GENERAL AND ANALYTICAL STUDY.
- Cooperative with Colorado State Univ.
See page 16.
- (3701) CURB OPENINGS.
- Cooperative with Colorado State Univ.
See page 17.
- (3705) ANALYTICAL STUDY OF LOCAL SCOUR.
- Cooperative with Colorado State Univ.
See page 17.
- (4101) UNSTEADY FLOW IN A LONG STORM DRAIN.
- Cooperative with Colorado State Univ.
See page 18.
- (1531) DETERMINATION OF WATERWAY AREAS.
- Cooperative with Univ. of Illinois.
See page 30.
- (856) HYDROLOGY OF STORM DRAINAGE SYSTEMS IN URBAN AREAS.
- Cooperative with Johns Hopkins Univ.
See page 36.
- (3805) OPEN CHANNEL JUNCTIONS FOR SUPERCRITICAL FLOW.
- Cooperative with Oregon State College.
See page 54.
- (2839) HYDRAULICS OF RIVER FLOW UNDER ARCH BRIDGES.
- Cooperative with Purdue University.
See page 58.
- (3166) HYDRODYNAMICS OF FLOW INTO CURB INLETS.
- Cooperative with Stanford University.
See page 67.
- (3597) CORRUGATED PIPE ROUGHNESS STUDY.
- Cooperative with U. S. Army Engineer Waterways Experiment Station, Corps of Engineers.
See page 141.
- (2435) HYDRAULICS OF PIPE CULVERTS.
- Cooperative with National Bureau of Standards.
See page 147.
- U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, Fluid Mechanics Section.
- (1478) WIND WAVES.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) Includes mathematical and experimental studies of (1) wind tides (setup), (2) growth of wind waves, and (3) surface traction of wind on wavy surfaces.
- (h) Report in preparation.
- (2435) HYDRAULICS OF PIPE CULVERTS.
- (b) Bureau of Public Roads.
- (d) Experimental; applied research.
- (e) To determine hydraulic characteristics of various types of culvert entrances and to develop inlets of improved design.
- (2436) FLOW OVER HYDROPHOBIC MATERIALS.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Experimental; applied research.
- (e) To determine augmented dissipation of hydrophobic disks and plates oscillated in various fluids.
- (h) Report in preparation.
- (3250) INERTIAL FORCES IN UNSTEADY FLOW.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Experimental; basic research.
- (e) Determination of inertia and drag coefficients of cylinders and plates when subjected to a varying monotonically varying flow.
- (h) Report in preparation.
- (3600) DAMPING OF PROGRESSIVE OSCILLATORY INTERNAL WAVES.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Theoretical and experimental; basic and applied research.
- (e) A study is being made of the velocity and damping of internal progressive oscillatory waves of a two-layer system.
- (h) "An Experimental Study of Internal Progressive Oscillatory Waves," by G. H. Keulegan and L. H. Carpenter, NBS Report No. 7319, August 12, 1961.
- (4400) MOTION AROUND A BODY IN A STRATIFIED FLUID.
- (b) Office of Naval Research, Dept. of the Navy.
- (d) Theoretical and experimental; basic and applied research.
- (e) A study is made of the internal waves produced by the horizontal motion of three-dimensional objects of revolution through a stably stratified liquid.
- U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU.
- Inquiries concerning the following projects, except as indicated, should be addressed to Mr. William E. Hiatt, Chief, Hydrologic Services Division, Weather

(1015) MEASUREMENT OF EVAPORATION.

- (b) Laboratory project.
- (d) Theoretical and field investigation; applied research.
- (e) Studies are directed toward the derivation of reliable procedures for estimating evaporation from reservoirs (existing and proposed) and land surfaces, utilizing readily available meteorological data and pan evaporation observations.
- (g) The Weather Bureau during Fiscal Year 1962 plans to add approximately 40 stations to the Class A pan evaporation network. Fourteen of these stations will be installed at various elevations on the windward and lee side of the Wasatch Range near Farmington, Utah. The elevation varies from 4800 to 8900 feet. The purpose of this network is to study the effect of elevation, aspect and exposure on evaporation. It is also planned to provide Six's thermometers for measuring water temperature at as many existing Class A stations as possible where currently water temperature observations are not made. With water temperature, air temperature and wind movement, it is possible to convert observed pan evaporation to estimates of lake evaporation using the method described in Weather Bureau Research Paper No. 38, "Evaporation from Pans and Lakes." The method of observing pan water temperatures will be changed. The Six's thermometer will be laid on the bottom of the pan rather than attached to a float. Observations at Silver Hill Observational Test and Development Center indicated that the water in the pan is isothermal; heating from the bottom during the daytime and cooling of the water surface at night resulted in overturning, both actions setting up convection currents that tend to keep the water isothermal. Field tests were made at several stations with different climatic regimes and the temperatures (floating and bottom) agreed within the accuracy of observation. Field testing of the experimental insulated fiberglass pan was continued at Observational Test and Development Center near Sterling, Va., Weather Bureau Airport Station at Las Vegas, Nev., and at Lake Overholser near Oklahoma City, Okla. Analysis of these data has not been completed. At the present time only a limited evaporation observational program is being conducted at the new Observational Test and Development Center near Sterling, Va. The evapotranspiration study to develop a basin accounting method for estimating soil moisture deficiency has been extended to several sections of the country. A program has been developed for the IBM-1620 computer for computing the potential evapotranspiration and doing the accounting.
- (h) "Comparative Evaluation of Instruments," by T. J. Nordenson and D. R. Baker, presented at 42nd Annual Meeting of AGU in Washington, D. C., April 18-21, 1961; submitted for publication.
"Multi-Capacity Basin Accounting for Predicting Runoff from Storm Precipitation," by M. M. Richards and M. A. Kohler, presented at National Meeting of the American Meteorological Society, Davis, Calif., June 20-22, 1961.

(1744) DEVELOPMENT OF RIVER FORECASTING METHODS.

- (b) River Forecast Centers for: Lower Ohio River Basin, Cincinnati, Ohio, Upper Ohio River Basin, Pittsburgh, Pa.; Susquehanna and Delaware River Basins, Harrisburg, Pa.; Missouri River Basin, Kansas City, Mo.; Columbia River Basin, Portland, Oreg.; Middle and Upper Mississippi River Basin, St. Louis, Mo.; Arkansas and Red River Basins, Tulsa, Okla.; New England and Hudson River Basins, Hartford, Conn.; South Atlantic and East

Gulf River Basins, Augusta, Ga.; West Gulf Drainage Basins, Ft. Worth, Tex.; and Middle Atlantic River Basins, Wash., D.C.

- (d) Theoretical and field investigation; operation and applied research.
- (e) The purpose of these investigations is to develop modern river forecast procedures for all ranges of flow for various streams of each basin. Procedures include: (1) Rainfall-runoff relations involving consideration of the physics of soil moisture, vegetative reception, transpiration, evaporation and geological features of the basins; (2) snow-melt forecasting relations involving consideration of the physics of snow and heat transfer; (3) unit hydrographs; and (4) streamflow routing procedures, based upon adaptations of basic hydraulic principles, using electronic or mechanical analogues. Studies have been initiated at several of the Centers to develop procedures for forecasting the formation and breakup of ice on rivers.
- (g) Forecasting procedures have been developed for key points; refinement of these procedures and development from other basins are under way. At the new Fort Worth River Forecast Center, it is planned to develop river forecasting procedures which will be adaptable to high-speed electronic computers. An IBM-1620 computer will be used for procedure development and in the forecasting operations.
- (h) "Flow Losses in Dry Sandy Channels," by J.H. Cornish, Journal of Geophysical Research; Vol. 66, No. 6, 1961.
"A Method of Estimating Basin Temperatures in New England and New York," by C. D. Hopkins, Jr., Journal of Geophysical Research, Vol. 65, No. 11, 1960.
"Average Antecedent Temperatures as a Factor in Predicting Runoff from Storm Rainfall," by C. D. Hopkins, Jr. and D. O. Hackett, Journal of Geophysical Research, Vol. 66, No. 10, 1961.
"Short Range Snowmelt Forecasts," by V. P. Schermerhorn, Proceedings Western Snow Conference, April 1961.
- (1745) WATER SUPPLY FORECASTS FOR WESTERN UNITED STATES.
- (b) Work being conducted in following field offices:
River Forecast Center - Portland, Oreg.,
Water Supply Forecast Unit - Salt Lake City, Utah,
River Forecast Center - Kansas City, Mo.,
Weather Bureau Office - Sacramento, Calif., and
River Forecast Center - Windsor Locks, Conn.
- (d) Theoretical and field investigation; operation and applied research.
- (e) The purpose of these investigations is the development of precipitation-runoff relations for water supply forecasting utilizing statistical methods to correlate precipitation during the winter with runoff during the melting season.
- (g) Water Supply Forecasts are prepared for about 350 points in the Western United States. These forecasts of water-year and residual flow are released in Monthly Water Supply Forecast Bulletins, January through May. This research program is of a continuing nature designed to improve and extend the present forecasting service.

(1751) MAXIMUM STATION PRECIPITATION.

- (b) Corps of Engineers, Department of the Army.
- (d) Analysis of data.
- (e) Tabulations of maximum recorded 1-, 2-, 3-, 6-, 12-, and 24-hour precipitation, for automatic recording rain-gage stations, by states.
- (h) Twenty-five states completed and published as parts of Weather Bureau Technical Paper No. 15; Oklahoma at printers; Michigan and Iowa in process.

(2437) UNITED STATES STORM CHARACTERISTICS PROJECT.

- (b) Soil Conservation Service, Department of Agriculture.
- (d) Theoretical and field investigation; applied research and design.
- (e) Studies to provide rainfall data for design criteria in estimating required capacities of hydraulic structures. Work includes:
 - (1) Development of a generalized relationship between depth, area, duration and frequency for areas up to 400 square miles, durations of 20 minutes to 24 hours, and return periods from 1 to 100 years; (2) development of a generalized portrayal of the probable maximum precipitation for areas up to 400 square miles, and durations up to 24 hours in the United States; and (3) combination of (1) and (2) for Hawaiian Islands and Alaska.
- (h) "Rainfall-Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," by D. M. Hershfield, Technical Paper No. 40, U. S. Weather Bureau, 1961.
"Generalized Estimates of Probable Maximum Precipitation and Rainfall Frequency Data for Puerto Rico and Virgin Islands for Areas to 400 Square Miles, Durations to 24 Hours, and Return Periods from 1 to 100 Years," Technical Paper No. 42, U. S. Weather Bureau, 1961.
"Estimating the Probable Maximum Precipitation," by D. M. Hershfield, Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, Paper 2933, September 1961.

(2438) STORM TIDE PREDICTIONS.

- (b) Laboratory projects.
- (c) Mr. D. Lee Harris, Office of Meteorological Research, U. S. Weather Bureau, Washington 25, D. C.
- (d) Theoretical and field investigation; basic and applied research.
- (e) The differences between the observed and predicted tides during storms are being studied with the goal of improving the accuracy of storm tide forecasting.
- (g) Empirical methods of forecasting these inundations are being developed and used in the Weather Bureau's hurricane and storm warning service. Continued improvement in these forecasts is expected to result from this research.
- (h) "Discussion of Technical Memorandum No. 120, The Prediction of Hurricane Storm-Tides in New York Bay," by D. L. Harris, Technical Memorandum No. 120-A, Beach Erosion Board, 1961, pp. 1-2.
"Storm Surge Observations in Hurricanes," Proceedings of the Second Technical Conference on Hurricanes, National Hurricane Research Project Report No. 50, U. S. Weather Bureau.
"Chesapeake Bay Hurricane Surges," by N. A. Pore, Chesapeake Science, Vol. 1, No. 3-4, December 1960.
"The Storm Surge," by N. A. Pore, Mariners Weather Log, Vol. 5, No. 5, September 1961.
"About the Mathematical Formulation of the Storm Surge," by H. G. Fontok, Proceedings of the Second Technical Conference on Hurricanes, National Hurricane Research Project Report No. 50, U. S. Weather Bureau, 1961 (In Press).
"Concerning the General Vertically Averaged Hydrodynamic Equations with Respect to Basic Storm Surge Equations," by H.G. Fontok, National Hurricane Research Project Report No. 51, U. S. Weather Bureau, 1961 (In Press).

(2943) METEOROLOGICAL RADAR TRANSPONDER (MRT) FOR REPORTING RAINFALL.

- (b) Laboratory project in cooperation with H. R. B. Singer Co., State College, Pa.

- (d) Field investigation; development and operation
- (e) A compact device, consisting of a tipping bucket rain gage and transponder, that can be installed in relatively remote areas. Activated by a pulse signal from the radar, the instrument transmits delayed pulse which appears on the radar scope indicating accrued amounts of precipitation. Investigations are continuing for application to the reporting of river and tide stage, and radio-active snow water-equivalent gage.
- (g) MRT-1 now operational, MRT-2 being built.
- (h) "Telemetering Precipitation Data Using a Radar Beacon," by D. R. Soltow and R. D. Tarble, Journal of Geophysical Research, Vol. 64, No. 11, November 1959.

(2944) PROBABLE MAXIMUM PRECIPITATION OVER CALIFORNIA BASINS.

- (b) Corps of Engineers, Department of Army.
- (d) Design and applied research.
- (e) Estimate of probable maximum precipitation over basins in California based on simple model of wind flow up orographic slopes, checked against December 1955 flood-producing storm, combined with non-orographic storm precipitation.
- (f) Completed.
- (h) "Interim Report. Probable Maximum Precipitation in California," Hydrometeorological Report No. 36, U. S. Weather Bureau, 1961.

(3251) PRECIPITATION DISTRIBUTION AS DETERMINED BY RADAR.

- (b) Laboratory project at Weather Bureau Office in Sacramento, Calif.
- (d) Theoretical and field investigation, operation and applied research.
- (e) A study is being undertaken to manually relate, within 100 n.m. of the radar, weather radar echoes over selected recording rain gages with the observed rainfall. The sampling area over each rain gage is indicated on the radarscope by a grid overlay where each grid represents about 20 square miles. An estimate of rainfall over each grid is made by use of a stepped-gain procedure and converting these db readings to estimated rainfall rates by means of a rainfall rate-echo intensity graph. This use of radar has application to flood forecasting, water supply forecasting and will also be used to determine a radar range correction value.
- (g) Data being collected.

(3601) STUDY OF TECHNIQUES FOR MEASURING RAINFALL BY REFERENCE TO RADAR ATTENUATION.

- (b) Laboratory project in cooperation with Stanford Research Institute, Menlo Park, Calif.
- (d) Experimental; development and applied research.
- (e) By measuring the attenuation of short wave length radar signals over a fixed course and relating it to the measured precipitation along the path of the radar beam, a relationship can be established enabling an instrument (to be developed) to monitor areas above damsites and small headwaters to alert downstream interests of heavy rainfall.
- (g) Over a path of 3.25 KM radar attenuation has been successfully correlated with observed rainfall. Incremental measurements of .10 inch/hour were made with radar attenuation errors of estimated rainfall in the order of magnitude of .10.
- (h) "Study of Techniques for Measuring Rainfall by Reference to Radar Attenuation," by Ronald T. H. Collis, under Weather Bureau Contract 9910, Stanford Research Institute Project 3367, April 1961.

(3602) EXTENSION OF RATING CURVES.

- (b) Laboratory project.
 - (d) Field investigation; operation and applied research.
 - (e) The flood forecasting procedures used by the Weather Bureau are primarily based on discharge. However, the flood warnings to be of any value must be in terms of stage (or elevation). This is accomplished by use of U. S. Geological Survey rating curves relating discharge to stage. Rating curves are defined only to the maximum observed stage of record. Therefore, it is imperative to devise a reliable method of extending rating curves in order to issue accurate stage predictions for the record breaking flood.
 - (g) Progress has been slow and no significant results are available at this time.
- (3920) FLOAT-TYPE RESISTANCE RIVER GAGE.
- (b) Laboratory project.
 - (d) Experimental; development.
 - (e) A device employing a Heliplot (multi-turn potentiometer) operated by a float or connected to an existing river gage and linked by wire or radio to an observation point (up to 3 miles by wire and 50 miles by radio). A reading is obtained by balancing the resistance in the system with a similar unit at the observation point. May be operated on AC or DC power.
 - (g) Initial field installations of units linked by land lines now operational; radio link still under development.
- (3921) PUNCHED-TAPE RECORDING, WEIGHING-TYPE PRECIPITATION GAGE WITH TELEMETERING CAPABILITY.
- (b) Laboratory project.
 - (d) Experimental; development.
 - (e) A fifteen-inch capacity, weighing-type battery-operated precipitation gage providing a punched tape record which can be machine processed, capable of over one month's unattended operation. Gage so designated that data can be telemetered through use of a "black box" attached to recording mechanism.
 - (g) Initial gage built and undergoing laboratory tests. Additional gages for testing being procured.
- (4401) BINARY-DECIMAL TRANSMITTER FOR USE WITH ANALOG-DIGITAL RECORDER.
- (b) Laboratory project in cooperation with Fischer & Porter Co.
 - (d) Experimental; design development.
 - (e) Black-box attachment for Analog-Digital Recorder (ADR) permitting interrogation by telephone or radio of river stage data.
 - (g) Initial installations undergoing field test.
- (4402) RADAR PRECIPITATION INTEGRATOR.
- (b) Laboratory project in cooperation with Stanford Research Institute, Menlo Park, Calif.
 - (d) Experimental; development.
 - (e) A system for reporting accrued precipitation using a stepped-gain approach with weather radar echoes at each point of a grid being quantized and recorded in pulsed digital form. The presentation is made on a series of electro-mechanical counters, set out in a map in positions corresponding to the grid, in units of depth of presentation. Because of the pulsed digital nature of the data it is readily possible to transmit it by narrow bandwidth links.
 - (g) Laboratory unit constructed.
 - (h) "Study into the Feasibility of Developing a System to Measure Precipitation by WSR-57 Radar," by Ronald T. H. Collis, under Weather Bureau Contract 10123, Stanford Research Institute Project 3727, October 1961.
- (4403) PROBABLE MAXIMUM PRECIPITATION AND SNOWMELT IN YUKON BASIN.
- (b) Corps of Engineers, Department of the Army.
 - (d) Design and applied research.
 - (e) Specification of weather factors that could produce maximum discharge and volume at Rampart Dam site and other sites on Yukon River in Alaska.
- U. S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY.
- (1221) STEADY STATE ELECTRIC FLOW NET MODELS.
- (b) Laboratory project.
 - (c) Mr. R. R. Bennett, U. S. Geol. Surv., Wash. 25, D.C.
 - (d) Applied research.
 - (e) Preparation of electric flow net models using graphite paper, conductive paints, resistor grids, etc.
- (1755) CHARACTERISTICS OF SAND CHANNEL STREAMS.
- (b) Laboratory project.
 - (c) Mr. R.W. Carter, U.S. Geol. Surv., Wash. 25, D.C.
 - (d) Field investigation; applied research.
 - (e) Compilation and analysis of data collected in a 1,900 foot reach of the Elkhorn River in Nebraska to evaluate bed roughness, extent of scour and fill, and sediment movement. Completed.
 - (f) "Flow Characteristics of Elkhorn River, near Waterloo, Nebraska," by E.W. Beckman, and L.W. Furness, 1961, U.S. Geol. Survey Water Supply Paper 1498-B.
 - (h)
- (2444) REDESIGN OF PRICE CURRENT METER.
- (b) Laboratory project.
 - (c) Mr. E.G. Barron, U.S. Geol. Surv., Columbus 12, Ohio.
 - (d) Experimental; development.
 - (e) To design a vane-type rotor for the Price current meter that can be mass-produced with identical rating calibration and is little affected by vertical velocity components or proximity to the water surface.
 - (g) Precision cast rotors of beryllium-copper, stainless steel, and aluminum are being tested to determine most appropriate material and hydrodynamical similarity of the individual rotors.
- (2688) MECHANICS OF AQUIFERS.
- (b) Laboratory project.
 - (c) Mr. J.F. Poland, U.S. Geological Survey, Sacramento, California.
 - (d) Field investigation; basic and applied research.
 - (e) To determine the principles and factors involved in the strain, deformation, and compaction of water-bearing rocks resulting chiefly from changes in hydrologic environment.
 - (h) "Near Surface Land Subsidence in Western San Joaquin Valley, California," by B.E. Lofgren, Jour. Geophys. Research, v. 65, no. 3, p. 1053-1062, 1960.
 - "Land Subsidence in the San Joaquin Valley, California, and its Effect on Estimates of Ground-Water Resources," by J.F. Poland, Internat. Assoc. Sci. Hydrol. Pub. 52, p. 324-335, 1960.
 - "Relation of Volumetric Shrinkage to Clay Content for Sediments from Subsidence Areas in San Joaquin Valley, California," by A.I. Johnson and D.A. Morris, U.S. Geol. Survey (in review).
- (2689) DIFFUSIONAL PROCESSES AND HYDRODYNAMICS OF SALT-FRESH WATER INTERFACE IN AQUIFERS.
- (b) Laboratory project.
 - (c) Mr. H. H. Cooper, Jr., U.S. Geol. Surv., Tallahassee, Florida.

- (d) Field and laboratory investigation; basic and applied research.
- (e) To determine the factors affecting the distribution of salt water in coastal aquifers subject to salt water encroachment.
- (h) "A Hypothesis Concerning the Dynamic Balance of Fresh Water and Salt Water in a Coastal Aquifer," by H. H. Cooper, Jr., Jour. Geophys. Res., v. 64, no. 4, p. 461-467, 1959.
 "The Pattern of Fresh-Water Flow in a Coastal Aquifer," by R. E. Glover, Jour. Geophys. Res., v. 64, no. 4, p. 457-459, 1959.
 "Cyclic Flow of Salt Water in the Biscayne Aquifer of Southeastern Florida," by F. A. Kohout, Jour. Geophys. Res., v. 65, no. 7, p. 2133-2141, 1960.
 "Salt Intrusion into Fresh-Water Aquifers," by H.R. Henry, Jour. Geophys. Res., v. 64, no. 11, p. 1911-1919, 1959.
 "Flow Pattern of Fresh and Salt Water in the Biscayne Aquifer of the Miami area, Florida," by F.A. Kohout, Internat'l. Assoc. Scientific Hydrol. Pub. 52, p. 440-448, 1960.
 "Salt Intrusion into Coastal Aquifers," by H.R. Henry, Internat'l. Assoc. Scientific Hydrol. Pub. 52, p. 478-487, 1960.
- (2690) MICROSCOPIC FLOW THROUGH POROUS MEDIA.
- (b) Laboratory project.
- (c) Dr. E.S. Simpson, U.S. Geol. Surv., Wash. 25, D.C.
- (d) Laboratory investigation; basic research.
- (e) To determine the factors affecting the pattern of microscopic flow of water and other liquids through porous media.
- (f) Completed.
- (h) "Transverse Dispersion in Liquid Flow through Porous Media," by E.S. Simpson, U.S. Geol. Survey Prof. Paper 411-C.
- (2692) ANALOG COMPUTER FOR ANALYSIS OF GROUND-WATER FLOW SYSTEMS.
- (b) Laboratory project.
- (c) Mr. H.E. Skibitzke, U.S. Geological Survey, Phoenix, Arizona.
- (d) Theoretical study and instrument development.
- (e) Development of the physical and mathematical theory of ground-water flow systems and construction of an analog computer for analyzing ground-water flow systems under transient conditions.
- (h) "Electronic Computers as an Aid to the Analysis of Hydrologic Problems," by H.E. Skibitzke, Internat'l. Assoc. Sci. Hydrol. Pub. 52, p. 347-358, 1960.
 "Electronics and Ground Water," by H. E. Skibitzke, Ariz. Sewage and Water Works Assoc. Bull., v. 20, no. 1, 1960.
- (2694) FLOW OF WATER OVER WEIRS AND SPILLWAYS.
- (b) Laboratory project.
- (c) Prof. C.E. Kindsvater, Georgia Institute of Technology, Atlanta, Georgia.
- (d) Library search, re-analysis and correlation of published data, and original research.
- (e) A comprehensive study of the discharge characteristics of practical forms of weirs and spillways. Objectives include the publications, in generalized form, of available experimental data.
- (2695) CONTINUOUS DISCHARGE RECORDS IN TIDAL STREAMS.
- (b) Laboratory project.
- (c) Mr. John Shen, U.S. Geol. Surv., Wash. 25, D.C.
- (d) Theoretical; applied research.
- (e) The purpose is to develop a mathematical system that describes the flow pattern and related channel characteristics for a tidal stream, and to ascertain the discharge in the reach.
- (g) A system of non-linear, hyperbolic, partial differential equations was developed, which describes the unsteady flow in a tidal reach. A solution by Fourier series was found unfeasible, but a solution by power-series proved satisfactory in tests on the Sacramento River and Three-Mile Slough in California, and for Vermillion River in Louisiana. This technique has been programmed for the Burroughs 200 computer. Another solution by the theory of characteristics is under study.
- (h) "Computation of Homogenous Flow in Tidal Reaches by Finite-Difference Method," by R.A. Baltzer, and John Shen, in Geol. Survey Research, 1961: U.S. Geol. Survey Prof. Paper 424-B.
 "Flow in Tidal Reaches," by R.A. Baltzer and John Shen, U.S. Geol. Survey Water-Supply Paper (in preparation).
- (2698) EVALUATION OF EFFECT OF CHANNEL STORAGE ON PEAK DISCHARGE.
- (b) Laboratory project.
- (c) Mr. W.D. Mitchell, U.S. Geol. Survey, Champaign, Ill.
- (d) Field investigation; basic research.
- (e) The objective is to develop parameters that describe the effect of channel storage in an areal correlation of peak flow.
- (f) Completed.
- (h) "Effect of Reservoir Storage on Peak Flow," by W.D. Mitchell, U.S. Geol. Survey Water Supply Paper 1580-C.
- (2699) UNIFORM FLOW IN OPEN CHANNELS.
- (b) Laboratory project.
- (c) Mr. H.J. Tracy, U.S. Geol. Surv., Atlanta 8, Ga.
- (d) Theoretical and experimental; basic research.
- (e) A comprehensive laboratory study of uniform flow in open channels.
- (h) "Resistance Coefficients and Velocity Distribution, Smooth Rectangular Channel," by H.J. Tracy and C.M. Lester, 1961, U.S. Geol. Survey Water Supply Paper 1592-A.
 "Variation of the Manning in a smooth, rectangular open channel," by C.M. Lester, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-C.
- (2702) ROUGHNESS AND WATER SEDIMENT MOVEMENT IN ALLUVIAL CHANNELS.
- (b) Laboratory project.
- (c) Dr. D. B. Simons, Geological Survey, Colo. State University, Fort Collins, Colorado.
- (d) Basic and applied research.
- (e) A study of mechanics of flow in alluvial channels using a large recirculating laboratory flume. Based upon a laboratory study and field studies, relationships which describe flow in alluvial channels are being developed. The study has been completed for four (4) bed materials. Regimes of flow, forms of bed roughness, resistance to flow relations, and sediment transport relations have been developed for the four sizes of sand investigated.
- (h) "Sonic Depth Sounder for Laboratory and Field Use," by E. V. Richardson, D. B. Simons and D. J. Posakony, U.S. Geological Survey Circular 450, 1961.
 "Forms of Bed Roughness in Alluvial Channels," by D. B. Simons and E. V. Richardson, Jour. of the Hydraulics Division, ASCE, v. 87, May 1961.
 "Unsteady Flow of Ground Water into a Surface Reservoir," by W. L. Hauschild and G. Kruse, Journal of the Hydraulics Division, ASCE, v. 86, July 1960.
 "Uniform Water Conveyance Channels in Alluvial Materials," by D. B. Simons and M. L. Albertson, Journal of the Hydraulics Div., ASCE, v. 86, May 1960.
- (2703) EVAPORATION SUPPRESSION.
- (b) Cooperative with Bureau of Reclamation and Texas A. and M. College.
- (c) Mr. G. E. Kober, U. S. Geol. Surv., Denver, Colo.

- (d) Field investigation.
 - (e) The purpose of this project is to develop methods, equipment, and techniques of applying and maintaining a monomolecular film for suppressing evaporation, and to measure the effectiveness of the film in reducing evaporation. Field testing of application techniques of these alkanols has been tried with varying success. Research in this field must continue until reliable methods are developed which are economically feasible in obtaining the maximum evaporation reduction. Both laboratory and field studies will be continued.
 - (g) Field experiments were completed at Lake Sahuaro, Arizona, and are being continued near Throckmorton, Texas, and Lake Cachuma, near Santa Barbara, Calif.
 - (h) "1960 Evaporation Reduction Studies at Sahuaro Lake, Arizona, and 1959 Monolayer Behavior Studies at Lake Mead, Arizona-Nevada, and Sahuaro Lake, Arizona," U.S. Bureau of Reclamation Chemical Engineering Laboratory Report No. SI-32, 1961.
 - "Evaporation Control Research 1959-60," by G. E. Koberg, U.S. Geological Survey, R. R. Cruse, Southwest Research Institute, and C. L. Shrewsbury, Southwest Agricultural Institute, being reviewed for U.S. Geological Survey water-supply paper.
- (2948) ANALOG MODEL ANALYZER FOR STEADY-STATE GROUND-WATER FLOW PROBLEMS.
- (b) Laboratory project.
 - (c) Mr. R. W. Stallman, U.S. Geol. Surv., Denver, Colo.
 - (d) Theoretical study and instrument development.
 - (e) Use of a variable-resistance grid analyzer in analyzing steady-state ground-water flow problems in which the transmissibility varies in space.
 - (h) "Calculation of Resistance and Error in an Electric Analog of Steady Flow through Nonhomogeneous Aquifers," by R. W. Stallman, U. S. Geol. Survey Water-Supply Paper 1544.
 - "An Electric Analog of Three-Dimensional Flow to Wells and its Application to Unconfined Aquifers," by R. W. Stallman, U.S. Geol. Survey open-file rept.
- (2949) ULTRASONIC FLOW METER.
- (b) U. S. Geological Survey.
 - (c) Mr. E. G. Barron, U. S. Geological Survey, Columbus 12, Ohio.
 - (d) Experimental; instrument development.
 - (e) The objective is to measure the average velocity in a natural channel by acoustic means.
 - (g) Instrument being tested at a field installation.
 - (h) "Development of an Ultrasonic Method for Measuring Stream Velocities," by H. O. Wires, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-B.
- (2950) SEDIMENT TRANSPORT AND CHANNEL ROUGHNESS IN NATURAL AND ARTIFICIAL CHANNELS.
- (b) Laboratory project.
 - (c) Mr. Thomas Maddock, Jr., U. S. Geological Survey, Washington 25, D.C.
 - (d) Basic research.
 - (e) Field and laboratory studies, original and other investigations will be analyzed in terms of sediment movement, channel roughness, shear distribution in channel prism and other effects on shape of natural channels.
- (3254) DISPERSION IN NATURAL STREAMS.
- (b) Atomic Energy Commission.
 - (c) Mr. R. G. Godfrey, U. S. Geological Survey, Washington 25, D.C.
 - (d) Theoretical and field investigation; basic research.
 - (e) To measure dispersion and relate dispersal patterns to stream-channel geometry, fluid properties, and flow characteristics.
- (g) Field tests completed for 6 study reaches. The observed dispersion patterns have been analyzed and compared to models based on theoretical considerations.
 - (h) "Observation of Unsteady Phenomena," by R. G. Godfrey, 1961, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-C.
 - "The Effect of Finite Boundaries on Measurement of Gold-198 with a Scintillation Detector," by B. J. Frederick, and R. G. Godfrey, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-D.
 - "Dispersion in Natural Channels," by R. G. Godfrey and B. J. Frederick, U. S. Geol. Survey Water Supply Paper (in preparation).
- (3255) ELECTROMAGNETIC FLOW METER.
- (b) Laboratory project.
 - (c) Mr. E. G. Barron, U. S. Geological Survey, Columbus 12, Ohio.
 - (d) Experimental; instrument design.
 - (e) To redesign, adapt, and repack the electromagnetic flow meter now used by the U.S. Navy, to measure velocity in open channels.
 - (g) Experimental model undergoing field tests.
- (3256) EFFECT OF ROUGHNESS CONCENTRATION ON OPEN CHANNEL FLOW.
- (b) Laboratory project.
 - (c) Dr. H. J. Koloseus, U. S. Geological Survey, Fort Collins, Colo.
 - (d) Experimental; applied research.
 - (e) To determine the effect of bed roughness on open channel flow by increasing the concentrations of 3/16-inch cubes cemented to the flume floors.
 - (h) "Flow in an Artificially Roughened Channel," by H. J. Koloseus and Jacob Davidian, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-B.
 - "The Role of the Froude Number in Open-Channel Resistance," by Hunter Rouse, H. J. Koloseus, and Jacob Davidian, 1961, paper presented at Ninth Convention of the International Assoc. Hydraulic Research.
- (3257) MEASUREMENT OF TOTAL SEDIMENT DISCHARGE OF COARSE SEDIMENTS.
- (b) Laboratory project.
 - (c) D. W. Hubbell, U. S. Geological Survey, Colorado State University, Fort Collins, Colorado.
 - (d) Analytical; applied research.
 - (e) A review of the types of equipment currently used to measure sediment moving as bed load and the preparation of a report covering criteria for sampler design and use.
 - (f) Inactive.
 - (h) Progress report in process of publication.
- (3260) SOIL-MOISTURE EQUIPMENT.
- (b) Laboratory project.
 - (c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U.S. Geological Survey, Denver, Colo.
 - (d) Laboratory and field investigation; applied research.
 - (e) Laboratory model and field comparative study of techniques and of various commercially available instruments for measuring soil moisture. New equipment may also be designed as result of study.
 - (g) Field and laboratory calibrations of neutron meter, tensiometers, moisture blocks and sampling equipment. Evaluation of neutron meter. Design of small-diameter fast-response tensiometer. Library research.
 - (h) "Measurement of Soil Moisture Under Field Conditions," by A. I. Johnson, U.S. Geol. Survey Water-Supply Paper 1619-U.
- (3261) MODEL STUDY FOR SALT WATER DIFFUSION.
- (b) Laboratory study.

- (c) Mr. A.I. Johnson, Chief, Hydrologic Laboratory, U. S. Geological Survey, Denver, Colo., or Mr. H.H. Cooper, Jr., Research Engineer, U.S. Geological Survey, Tallahassee, Florida.
 - (d) Experimental; applied research.
 - (e) Model study is being used to study diffusion at the interface between fresh and salt water. Variable movement of interface simulates effects of various amplitudes and periods of tidal action.
 - (g) Design and construct plastic model and conductivity-recording equipment; one test run with fine-sand size glass beads and two test runs on medium sand completed.
 - (h) "Oscillating Interface Used in Laboratory Determination of Dispersion Coefficient," by W. K. Kulp, U. S. Geol. Survey Prof. Paper 424-C.
- (3262) SMALL-DIAMETER OBSERVATION-WELL EQUIPMENT AND TECHNIQUES.
- (b) Laboratory project.
 - (c) Mr. A.I. Johnson, Chief, Hydrologic Laboratory, U. S. Geol. Survey, Denver, Colo.
 - (d) Laboratory and field investigation; applied research.
 - (e) Design and evaluate equipment for recording depth-to-water in small-diameter wells; test in model well in laboratory and on ground-water wells under field conditions.
 - (f) Completed.
 - (g) Design and construct model well; construct small-diameter observation wells in field; design and construct equipment to be adapted to water-state recorders on small-diameter wells; evaluation on model well.
 - (h) "Evaluation of Equipment for Measurement of Water Level in Small Diameter Wells," by Eugene Shuter and A. I. Johnson, U. S. Geol. Survey Circular 453.
"Application of Transducers to Water Resources Studies," by F. C. Koopman (in review).
- (3263) SPECIFIC YIELD AND RELATED PROPERTIES.
- (b) Cooperative with the State of California.
 - (c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U.S. Geological Survey, Denver, Colo.
 - (d) Laboratory and field investigation; basic and applied research.
 - (e) Theoretical, laboratory and field study of specific yield, and related properties, such as moisture equivalent, field capacity, moisture tension, unsaturated permeability and time-drainage relationships, as related to ground-water storage. Evaluation of existing, and possible development of new, methods for determining these properties.
 - (g) Library research; laboratory study in progress or completed of factors affecting column drainage, centrifuge moisture equivalent, moisture tension and unsaturated permeability.
 - (h) "Specific Yield and Related Properties of Earth Materials, Part 1, An Annotated Bibliography," by A. I. Johnson, D. A. Morris, and R. C. Prill, U. S. Geol. Survey open-file report (1961).
"Specific Yield and Related Properties of Earth Materials, Part 2, Column Drainage and Moisture Equivalent of Artificial Materials," by A. I. Johnson, R. C. Prill, and D. A. Morris, U. S. Geol. Survey Water-Supply Paper 1662-A; also published as an open-file report (1961).
"Mechanical Uniform Packing of Porous Media," by D. A. Morris and W. K. Kulp, U. S. Geol. Survey Prof. Paper 424-C.
"Comparison of Drainage Data Obtained by the Centrifuge and Column Drainage Methods," by R. C. Prill, U. S. Geol. Survey Prof. Paper 424-C.
- (3264) SUBSURFACE EXPLORATION EQUIPMENT AND TECHNIQUES.
- (b) Laboratory project.
- (c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U. S. Geological Survey, Denver, Colo.
 - (d) Laboratory and field investigation; applied research.
 - (e) Evaluate and adapt subsurface exploration equipment and techniques, such as gamma ray and electric loggers, fluid velocity and conductivity loggers, temperature loggers, power augers and core samplers, for solving ground water occurrence problems.
 - (g) Portable temperature logger nearly completed; core samplers designed and commercial models procured and compared under field conditions; power augering equipment and techniques evaluated; evaluation in progress of gamma-ray conductivity and temperature logging equipment for salt-water encroachment and waste disposal problems. Library research in progress.
 - (h) "Selected References on Laboratory and Field Methods in Ground-Water Hydrology," by A. I. Johnson, (in review).
"A Field Method for Measurement of Infiltration," by A. I. Johnson, U. S. Geol. Survey Water-Supply Paper 1544-E, also published as an open-file report (1961).
"Geophysical Exploration of Wells as an Aid in Location of Salt-Water Leakage, Alameda Plains, California," by R. P. Moston and A. I. Johnson, U. S. Geol. Survey Prof. Paper 424-C.
"Subsurface Hydrologic Exploration with Inflatable Packers," by F. C. Koopman, J. H. Irwin, and E. D. Jenkins, U. S. Geol. Survey (in review).
- (3265) INVESTIGATION OF VADOSE FLOW THROUGH HOMOGENEOUS ISOTROPIC MEDIA.
- (b) Laboratory project.
 - (c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U. S. Geological Survey, Denver, Colo.
 - (d) Experimental; basic and applied research.
 - (e) Laboratory model study of infiltration of fluids from surface pits into a thick unsaturated zone above the water table.
 - (g) Model tank designed and constructed; several test runs with beads of different particle size completed; library research; test runs photographed by slide and movie.
 - (h) Silent, color, lapse-time movie on second, third and fourth phase of model study completed.
"Vadose Flow in Layered and Non-Layered Materials," by W. N. Palmquist, Jr., and A. I. Johnson; U.S. Geol. Survey (in review).
"Model Study of Vadose Flow Through Porous Media," by W. K. Kulp, U. S. Geol. Survey (in review).
- (3603) SURFACE FOLLOWER.
- (b) Laboratory project.
 - (c) Mr. E. G. Barron, U. S. Geological Survey, Columbus 12, Ohio.
 - (d) Experimental; design.
 - (e) The surface follower is designed to operate a recorder while following the level of the water in a 2-inch vertical pipe. A switch in a "float" closes either the up or down circuit which rotates a drum raising or lowering the float. A shaft input recorder is coupled to the drum.
 - (g) Production units undergoing field tests.
- (3604) TRANSPORT OF RADIONUCLIDES BY FLUVIAL SEDIMENT.
- (b) Atomic Energy Commission.
 - (c) Mr. D. W. Hubbell, U. S. Geological Survey, Colorado State University, Fort Collins, Colorado.
 - (d) Field investigation; basic research.
 - (e) Study of dispersion, transportation, and concentration of radionuclides by stream sediments for representative hydrologic and geologic environments.

- (g) Preliminary findings on the distribution of radioactive sand particles released in the North Loup River near Purdum, Nebraska, showed that the downstream distribution along the channel was at first skewed in the upstream direction but tended to approach normal after several days. Core samples showed that the tracer particles were randomly distributed vertically throughout the depth of bed-load movement. The zone of maximum concentration of tracer particles moved downstream at a rate of about 75 feet per day.
- (h) Report in preparation.
- (3605) MINERALOGY OF FLUVIAL SEDIMENTS.
- (b) Atomic Energy Commission.
(c) Mr. V. C. Kennedy, U. S. Geological Surv., Denver, Colo.
(d) Laboratory and field investigations.
(e) Study of the mineralogy and cation-exchange capacity of fluvial sediments for typical hydrologic and geologic environments.
(g) Preliminary observations show the exchange capacity of some sand fractions to be 30 percent and some silt fractions to be 80 percent of that for the corresponding clay fraction. This suggests that appreciable quantities of clay may be adhering to sand and silt particles or that clay aggregates are present.
- (3606) STREAM CHANNEL GEOMETRY AS RELATED TO FLOOD FREQUENCY.
- (b) Laboratory project.
(c) Mr. F. A. Kilpatrick, U. S. Geological Survey, Atlanta 8, Georgia.
(d) Field investigation; basic research.
(e) The study is pointed toward finding a relation between channel characteristics (bank-full stage, bed slope, etc.) and flood frequency.
(f) Completed.
(g) "Channel Geometry of Piedmont Streams as Related to Frequency of Floods," by F. A. Kilpatrick and H. H. Barnes, Jr., U. S. Geol. Survey Water-Supply Paper (in preparation).
- (3607) BATTERY OPERATED DIGITAL RECORDER.
- (b) Laboratory project.
(c) Mr. E. G. Barron, U. S. Geological Survey, Columbus 12, Ohio.
(d) Field investigation; operation.
(e) To develop a battery operated digital punch to record stream flow data. A shaft rotation input becomes a 16 channel parallel code output on paper tape.
(f) Completed.
(g) Production units being installed.
- (3923) DISTRIBUTION OF BOUNDARY SHEAR IN OPEN CHANNEL FLOW.
- (b) Laboratory project.
(c) Mr. R. W. Carter, U. S. Geol. Survey, Wash. 25, D.C.
(d) Experimental; applied research.
(e) Shear plates will be used in a flume to measure boundary shear in open-channel flow. If an accurate measure is obtained, the indirect methods of shear determination will be evaluated.
(g) A shear plate-beam balance device to measure fluid drag along the flume wall gave anomalous behavior at relatively high (0.7) Froude numbers. A strain-gage type shear plate has been designed and is being tested.
- (3924) GAGING FLOW THROUGH TURBINES.
- (b) Atomic Energy Commission.
(c) Mr. B. J. Frederick, U. S. Geological Survey, Oak Ridge, Tennessee.
(d) Experimental; applied research.
(e) To develop a method of rating turbines with use of radioisotopes as a tracer similar to "salt dilution" method.
- (g) Test method and instrumentation being designed.
- (3925) SURGES IN NATURAL CHANNELS.
- (b) Laboratory project.
(c) Mr. S. E. Rantz, U. S. Geological Survey, Menlo Park, California.
(d) Field investigation; applied research.
(e) To test application of classic wave theory in a natural channel.
(f) Completed.
(h) "Surges in Natural Channels," by S.E. Rantz, 1961, U. S. Geol. Survey Water Supply Paper 1369-C.
- (3926) GAGING OF SHALLOW MOUNTAIN STREAMS.
- (b) Laboratory project.
(c) Mr. R. G. Godfrey, U. S. Geol. Surv., Wash. 25, D.C.
(d) Experimental; applied research.
(e) The use of radioactive tracers for gage streamflow is feasible. Portable lightweight equipment is needed to sense and record the tracer concentration. Development is underway of a suitable probe to measure flow in shallow mountain streams.
(f) Discontinued.
- (3927) DEPTH-DISCHARGE RELATIONS IN ALLUVIAL STREAMS.
- (b) Laboratory project.
(c) Mr. R. W. Carter, USGS, Wash. 25, D.C.
(d) Field investigation; basic research.
(e) To determine the cause of an abrupt discontinuity in the depth-discharge relation between the dune-bed form and the plane-bed form in an alluvial stream.
(f) Completed.
(g) The critical point of discontinuity is dependent upon temperature. The resistance to flow for discharges beyond the discontinuity is related to bed material size.
(h) "Depth-discharge Relations of Alluvial Channels," by D. R. Dawdy, 1961, U.S. Geol. Survey Water Supply Paper 1498-C.
- (3928) EFFECT OF URBANIZATION ON PEAK DISCHARGE.
- (b) Laboratory project.
(c) Mr. R. W. Carter, USGS, Wash. 25, D.C.
(d) Field investigation; applied research.
(e) To develop a general method of predicting the frequency of flood discharges from developed areas based on all available hydrologic information.
(f) Completed.
(g) Equation determined expressing decrease in infiltration rate, and decrease in log time between rainfall excess and flood wave in channel for suburban development in vicinity of Washington, D.C.
(h) "Magnitude and Frequency of Floods in Suburban Areas," by R. W. Carter, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-B.
- (3929) USE OF AERIAL PHOTOGRAPHS AND MAPS IN HYDROLOGIC STUDIES.
- (b) Laboratory project.
(c) Mr. W. J. Schneider, USGS, Wash. 25, D.C.
(d) Field investigations; applied research.
(e) Objective is to determine possible relationships between basin characteristics and low stream flow for areal studies; and establish criteria for depicting streams on topographic maps to meet needs in hydrologic investigations.
(g) In two study areas in Georgia, streamflow becomes perennial at abrupt beginnings of incised stream channels; in the Tired Creek basin, these abrupt beginnings can be determined on aerial photographs from an associated characteristic pattern of vegetation.

- tation.
- (h) "A Note on the Accuracy of Drainage Densities Computed from Topographic Maps," by W. J. Schneider, 1961, Jour. Geophys. Research, v. 66, no. 10, pp 3617-3618.
- (3930) FLOODS FROM SMALL AREAS.
- (b) Laboratory project.
- (c) Mr. W. D. Mitchell, USGS, Champaign, Ill.
- (d) Field investigation; applied research.
- (e) Purpose is to provide information and develop methods to solve small basin drainage structure design problems.
- (g) Data at 50 small basin sites have been collected and hydrograph characteristics determined for 15 of these sites.
- (3931) SOURCE OF BASE FLOW OF STREAMS.
- (b) Laboratory project.
- (c) Mr. F. A. Kilpatrick, USG, Wash. 25, D.C.
- (d) Field investigation; applied research.
- (e) Purpose is to define the source, amount and distribution of base flow of streams.
- (g) Field data being collected in Yellow River Basin in Georgia.
- (3932) AREAL ANALYSIS OF LOW FLOWS.
- (b) Laboratory project.
- (c) Mr. H. C. Riggs, USGS, Wash. 25, D. C.
- (d) Field investigation; applied research.
- (e) Objective is to develop general expressions relating low flow characteristics of stream-flow at one or more sites with the basin characteristics of the area. Purpose is to increase the usefulness of short and intermittent records of streamflow.
- (f) Completed.
- (g) The slope of the low-flow frequency curve is related to drainage area, and the slope of the base-flow recession curve. A method of defining the base-flow recession curve is developed.
- (h) "Sources of Low Flows," by H. C. Riggs, U.S. Geol. Survey publication (in preparation).
 "Regional Low Flow Frequency Analysis," by H. C. Riggs, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-B.
 "Rainfall and Minimum Flows Along the Tallapoosa River, Alabama," by H. C. Riggs, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-B.
- (3933) EVALUATION OF STATISTICAL PROCEDURES IN HYDROLOGY.
- (b) Laboratory project.
- (c) Dr. N. C. Matalas, USGS, Wash. 25, D.C.
- (d) Experimental; applied research.
- (e) With respect to three problems, the objectives are as follows:
 (1) To modify regression analyses to account for inter-station correlation; (2) to define the statistical properties of tree ring data; and (3) to define economic decisions based on water forecasts so as to maximize the average income in dollars over a period of years.
- (g) For a simple linear regression model, assuming that the dependent variable consisted of a set of interdependent values, the expectations and variances of the regression constant, the regression coefficient, and an estimated value of the dependent variable were derived, and the tests of significance were modified to account for the interdependence.
- A statistical appraisal indicates that tree ring data are not randomly distributed in time. The large values of serial correlation suggest that the non-randomness cannot be attributed entirely to climatic factors, but is perhaps due to the botanical processes of growth. Thus sequences of high or low values of tree growth are not necessarily indicative of wet or dry periods. A statistical method was outlined, whereby economic decisions based on water forecasts could be made so as to maximize average income in dollars over a period of years.
- (h) "Effect of Interstation Correlation on Regression Analysis," by N. C. Matalas and M. A. Benson, 1961, Jour. Geophys. Research, v. 66, no. 10.
 "Probability Distribution of Low-Flows," by N. C. Matalas, 1961, U. S. Geol. Survey Water Supply Paper (in preparation).
 "Autocorrelation of Rainfall and Streamflow Minimums," by N.C. Matalas, 1961, U. S. Geol. Survey Water Supply Paper (in preparation).
- (3935) FLOOD PLAIN ZONING IN SUBURBAN AREAS.
- (b) Laboratory project.
- (c) Mr. D. G. Anderson, USGS, 300 South Payne St., Fairfax, Virginia.
- (d) Field investigation; applied research.
- (e) To determine magnitude and frequency of flood discharges from records of short duration and develop a method to describe the water-surface profile for a flood of a given frequency at all points along the stream channel.
- (g) Field data being obtained; flood-plain mapping almost completed.
- (h) "Flood Inundation Study of Cameron Run Basin in Virginia," by D. G. Anderson, open-file report, U. S. Geol. Survey.
- (3936) FLOOD-FREQUENCY RELATIONS WITHIN NEW ENGLAND.
- (b) Laboratory project.
- (c) Mr. M. A. Benson, USGS, Wash. 25, D. C.
- (d) Field investigation; applied research.
- (e) Objective is to understand the basic causative factors affecting peak flows and to improve the methods of flood-frequency analysis.
- (f) Completed.
- (g) Historical-flood data permitted extension of flood knowledge to 300 years. Multiple-correlation analysis led to formulas defining annual peak discharges with recurrence intervals from 1.2 to 300 years in terms of 6 variables: 3 topographic, 2 meteorologic and 1 orographic.
- (h) "Evolution of Methods and Techniques for Evaluating the Occurrence of Floods," by M.A. Benson, U. S. Geol. Survey Water Supply Paper 1580-A (in press).
 "Factor Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain," by M. A. Benson, 1961, U. S. Geol. Survey Water Supply Paper 1580-B (in press).
- (3937) FLOOD-FREQUENCY RELATIONS IN A SEMIARID AREA.
- (b) Laboratory project.
- (c) Mr. M. A. Benson, USGS, Wash. 25, D. C.
- (d) Field investigation; basic research.
- (e) Objective is to understand the basic causative factors affecting peak flows and to improve the methods of flood-frequency analysis.
- (f) Completed.
- (g) Formulas have been developed for defining annual peak discharges with various recurrence intervals in terms of drainage area, stream length, storage, rainfall intensity, and number of thunderstorm days.
- (h) "Flood-Frequency Relations in a Semiarid Area," by M. A. Benson, U. S. Geol. Survey Water-Supply Paper (in preparation).
- (3938) FREQUENCY OF DEFICIENT DISCHARGE FOR PERIODS OF SELECTED LENGTHS.
- (b) Laboratory project.
- (c) Mr. J. R. Crippen, USGS, Wash. 25, D.C.
- (d) Field investigation; applied research.
- (e) Objective is to develop a method of low-flow frequency analysis that can predict comparable results from either a short-term or a long-term stream-flow record.

- (f) Completed.
(g) Report in preparation.
- (3939) STUDY OF RADIOACTIVE WASTES, CLINCH RIVER, TENNESSEE.
- (b) Atomic Energy Commission.
(c) Mr. P.H. Carrigan, U. S. Geological Survey, Oak Ridge, Tennessee.
(d) Field investigation; applied research.
(e) Purpose is to undertake a comprehensive study of the entry, movement, location and fate of radioactive wastes discharged into the Clinch River by the Oak Ridge National Laboratory.
(g) Field investigation being conducted.
- (3940) THE TREND OF RUNOFF AND SEDIMENT YIELD, BRANDYWINE CREEK BASIN, PENNSYLVANIA AND DELAWARE.
- (b) Laboratory project.
(c) Mr. R. O. R. Martin and Mr. H. P. Guy, U.S. Geological Survey, Washington 25, D.C.
(d) Field investigation; applied research.
(e) Objective is to appraise and determine the changes in runoff and sediment yield resulting from changes in land use.
(f) Completed.
(g) Final report in preparation.
- (3941) EFFECT OF REFORESTATION ON STREAM FLOW.
- (b) Laboratory project.
(c) Mr. W. J. Schneider, USGS, Wash. 25, D.C.
(d) Field investigation; applied research.
(e) Purpose is to define the relation between reforestation and stream flow.
(f) Completed.
(g) Tree growth over a 25 year period has reduced total runoff from reforested areas by as much as one-third. The magnitude of peak discharges also has been altered, with about six out of seven current peaks reduced up to as much as 60 percent, and one out of seven increased.
(h) "Effect of Reforestation on Streamflow in Central New York," by W. J. Schneider and G. R. Ayer, 1961, U. S. Geol. Survey Water Supply Paper 1602.
"Reduction in Peak Discharges Associated with Reforestation," by W. J. Schneider, 1961, Forest Science, v. 7, no. 3, p. 232-237.
"Changes in Snowmelt Runoff Caused by Reforestation," by W. J. Schneider, 1961, Proceedings, Western Snow Conference, Spokane, Washington.
"Flood Frequencies as Related to Land Use," by W. J. Schneider, Bulletin of International Assn. of Scientific Hydrology, Louvain, Belgium.
- (3942) ERRORS IN DISCHARGE MEASUREMENTS.
- (b) Laboratory project.
(c) Mr. I. E. Anderson, USGS, Wash. 25, D. C.
(d) Experimental; applied research.
(e) To identify the source, magnitude, distribution, and effect of various errors, in discharge measurements, on the results obtained.
(f) Completed.
(g) U.S.G.S. methods satisfactory but less demanding standards yield acceptable results.
(h) Final report in preparation.
- (3943) USE OF PRECIPITATION RECORDS IN EXTENDING STREAMFLOW DATA.
- (b) Laboratory project.
(c) Mr. R. O. R. Martin, USGS, Wash. 25, D. C.
(d) Field investigation; applied research.
(e) Objective is to develop a practicable method of using the precipitation records to augment short-term streamflow records and to test the extent of the improvement in reliability.
(g) Correlation studies being made.
- (3944) AUTOMATIC COMPUTATION OF DAILY DISCHARGE RECORDS.
- (b) Laboratory project.
(c) Mr. W. L. Isherwood, USGS, Wash. 25, D. C.
(d) Experimental; operation systems.
(e) To develop a practical system of collecting records of river stages in a form suitable for automatic computation through a high speed computer with print out acceptable for offset reproduction.
(g) Digital recorder program operational for 260 gaging sites; records processed routinely on magnetic tape, suitable for offset reproduction.
(h) "Digital Recorders and Computer Techniques," by W. L. Isherwood, in Geological Survey Research, 1961, U. S. Geol. Survey Prof. Paper 424-A.
- (3945) STANDARD STATISTICAL ANALYSES OF STREAMFLOW RECORDS.
- (b) Laboratory project.
(c) Mr. C. R. Showen, USGS, Wash. 25, D.C.
(d) Experimental; operation.
(e) To develop operational systems and programs for automatic computation of statistical analyses of streamflow records.
(g) Programs for duration tables, low-flow and high-flow summaries for consecutive periods of various time periods now operational.
- (3948) SEDIMENT TRANSPORT PARAMETERS IN SAND BED STREAMS.
- (b) Laboratory project.
(c) Mr. J. K. Culbertson, USGS, Albuquerque, New Mexico.
(d) Field and office research.
(e) Field and theoretical investigation of sediment transportation in sand bed streams. Specifically included are hydraulic and sediment data for the Rio Grande.
(h) Report in process.
- (3949) FACTORS AFFECTING BED-MATERIAL DISCHARGE OF SAND BED STREAMS.
- (b) Laboratory project.
(c) Mr. B. R. Colby, USGS, Lincoln, Nebr.
(d) Field and office research.
(e) Field and theoretical investigation of bed-material discharge of sand bed streams utilizing available sediment-load data for a range of width/depth ratios.
(g) Mean velocity is found to be the dominant factor that influences the transport of sand per unit width in a sand bed stream. The effect of depth of flow seems to be complex and variable. High concentrations of fine sediment may greatly increase the discharge of sands in a stream like the Rio Puerco in New Mexico.
(h) "Studies of Flow in Alluvial Channels," U. S. Geological Survey Water Supply Paper 1498. D. "Effect of Depth of Flow on Discharge of Bed Material," by B. R. Colby, 1961.
Two reports in preparation.
- (3951) HYDROLOGY OF ARID AND SEMIARID REGIONS.
- (b) Laboratory project.
(c) Mr. Garald G. Parker, USGS, Denver, Colo.
(d) Field investigations; both basic and applied research.
(e) Several research stations have been or are being established in western States.
- (3952) STUDY OF MECHANICS OF HILLSLOPE EROSION.
- (b) Laboratory project.
(c) Dr. S. A. Schumm, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to study the mechanics of the erosion of hillslopes under various physical conditions, and to appraise

the relative influence of each factor involved in hillslope erosion in semiarid and arid environments. Studies include quantitative measurements of hillslope erosion, and to the extent possible, measurements of the contributing or related factors. Such information is needed to determine the amount of sediment derived from hillslopes and to provide guidance in planning erosion control measures. Studies are in progress in several areas in eastern and western Colorado and western Utah.

(g) Two reports in preparation.

(3953) BASIC RESEARCH IN VEGETATION AND HYDROLOGY.

- (b) Laboratory project.
- (c) Dr. R. S. Sigafos, USGS, Arlington, Va.
- (d) Field investigation.
- (e) The purpose of this project is to study the interrelationship between vegetation and geomorphic processes by comparing qualitative differences in distribution and form of plants with selected geologic and hydrologic variables. This comparison is prerequisite to establishment of methods to measure botanical parameters quantitatively. The immediate objectives will be to identify and map species limited to flood plains, to adjoining uplands, to alluvial fans, terraces, coves and ridges; to study relationship between forest development and flood frequency, and to determine the effect of land use upon changes in vegetation.
- (g) Four reports in preparation or scheduled.
- (h) "Botanical Evidence of Modern History of Nisqually Glacier, Washington," by R. S. Sigafos and E. L. Hendricks, published in U. S. Geological Survey Professional Paper 387-A, 1961.

(3954) CHARACTERISTICS OF GLACIER-FED STREAMS.

- (b) Laboratory project.
- (c) Dr. R. K. Fahnestock, USGS, Fort Collins, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to study the channel characteristics of streams below active glaciers, especially those carrying substantial amounts of debris which is sorted and transported by meltwater. It should assist developing an understanding of glacial outwash deposits, both present and past, in other areas. This study should also add to both the knowledge of the influence of diurnal fluctuations in flow on the characteristics of alluvial channels and to the knowledge of long term response of stream channels to glacier fluctuations. The project is carried on at White River below Emmons Glacier, Mt. Rainier, Wash., flume studies are carried out at Colorado State University.
- (h) "Morphology and Hydrology of a Glacial Stream - White River, Mt. Rainier, Washington," by R. K. Fahnestock, U.S. Geological Survey Professional Paper 422-A, is being processed.
- "Competence of a Glacial Stream," by R. K. Fahnestock, published in U. S. Geological Survey Professional Paper 424-B, Article 87, 1961.

(3955) DOWNSTREAM EFFECT OF DAMS, DIVERSIONS AND IRRIGATION DRAINS ON ALLUVIAL CHANNELS.

- (b) Laboratory project.
- (c) Dr. M.G. Wolman, Johns Hopkins University, Baltimore, Md.
- (d) Field investigation.
- (e) The purpose of the project is to determine the downstream effect the above types of structures exert on alluvial channels. All available data are to be gathered and summarized on channel surveys before and after construction. This will be accomplished insofar as possible by correspondence with State, Federal, and local agencies.
- (g) Report in preparation.

(3956) LONG-TERM HYDROLOGIC TRENDS AS INDICATED BY GLACIERS.

- (b) Laboratory project.
- (c) Dr. M.F. Meier, USGS, Tacoma, Washington.
- (d) Field investigation.
- (e) The purpose of this project is to learn more of the mechanics of glaciers and to relate ice thickness, velocity, slope, surface water flow, streamline inclination, and ablation. The hydrology of alpine basins, including snow fields and ice-covered areas, is important because of the relation of climate, precipitation, snow melt and storage effects on the water resources of northern and high-elevation areas. The project consists of a basic research study in fundamental problems of glacier regime, studies of long-term fluctuations in hydrologic factors, and relations between climatic and hydrologic factors. Comparisons will be made between the regime nourishment factors and activity of two similar valley glaciers located in different climatic environments. Primary study area: South Cascade Glacier, Washington.
- (g) Several reports in preparation.
- (h) "Distribution and Variation of Glaciers in the United States Exclusive of Alaska," by Mark F. Meier and others, Publication 54 of International Association of Hydrology.
- "Mass Budget of South Cascade Glacier, 1957-60," by Mark F. Meier, published in U. S. Geological Survey Professional Paper 424-B, Article 86, 1961.
- "Distinctive Characteristics of Glacier Runoff," by Mark F. Meier and W.V. Tangborn, published in U. S. Geological Survey Prof. Paper 424-B, Article 7, 1961.

(3957) THE HYDROLOGY OF A PORTION OF THE HUMBOLDT RIVER VALLEY.

- (b) State of Nevada and U. S. Bureau of Reclamation.
- (c) Mr. T.W. Robinson, USGS, Menlo Park, Calif.
- (d) Field investigation.
- (e) The purpose of this project is to determine how the available water in Humboldt River valley might better be utilized. The following hydrologic data will be collected and studied: (1) Runoff characteristics and magnitude of use of surface waters; (2) the specific yield of sediments in the flood plain and the magnitude and extent of water-level fluctuations in the ground-water reservoir; (3) the use of water by greasewood and willows; (4) variations in chemical quality of the water in the flood plain; (5) amount of underflow at Comus and Rose Creek to be determined by means of pumping tests of exploratory holes; and (6) amount of ground water from tributary valleys, to be determined on the basis of chemical analyses and low-flow measurements. The General Hydrology Branch has furnished the project leader and will determine the amount of water used by greasewood and willows by use of tanks (lysimeters) similar to those used in the Buckeye project. Site is near Winnemucca, Nevada, in the Humboldt River Valley.
- (g) Eight evapotranspirometers were installed during the 1961 season. These will be used for measuring water use as follows: two for greasewood, three for willow, and three for rabbitbrush.

(3958) THE EFFECT OF EXPOSURE ON SLOPE MORPHOLOGY.

- (b) Laboratory project.
- (c) Mr. R. F. Hadley, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to determine the morphologic and hydrologic differences existing among slopes of various exposures and to measure the resulting effects on erosion, soil moisture, and vegetational cover. Also, the effect of differential

- exposure on drainage-basin evolution will be investigated. Sites for study are several selected small areas in Wyoming, Colorado, and New Mexico.
- (g) A report on certain phases of project in preparation.
- (h) "Some Effects of Microclimate on Slope Morphology and Drainage Basin Development," by R. F. Hadley, U. S. Geological Survey Professional Paper 424-B, Article 16, 1961.
- (3959) LONG-TERM CHRONOLOGIES ON HYDROLOGIC EVENTS.
- (b) Laboratory project.
- (c) Mr. W. D. Simons, USGS, Tacoma, Washington.
- (e) The purpose of this project is to provide information on flood and drought frequencies and other critical hydrologic events from the history of major river basins. Data will be sought to evaluate long-term fluctuation in water supply to determine whether or not there has been either an upward or downward trend during the last 2 or 3 centuries. Such data will include crop records, news items, historical records, tree-ring data and lake levels. Efforts will be made to obtain useful data from anthropological research studies in the Pacific Northwest. This study would provide additional knowledge on probable frequency and duration of critical hydrologic events especially droughts for each major river basin. The first investigation would be in the Columbia River basin.
- (h) "Recent Hydrologic Trends in the Pacific Northwest," by W. D. Simons, U. S. Geol. Survey Professional Paper 424-B, Article 8, 1961.
- (3960) ANALYSIS OF SURFACE-GROUND WATER RELATIONS, HOP BROOK BASIN, MASSACHUSETTS.
- (b) Laboratory project.
- (c) Mr. J. C. Kammerer, USGS, Boston, Mass.
- (d) Field investigation.
- (e) The purpose of this project is to observe and evaluate some of the interrelated responses of ground and surface water to conditions and changes of climate and ecology characteristics of the spring, summer, and fall season, with particular reference to 3 or 4 specific sites within the basin, as well as some basinwide effects, such as the changes in upstream limits of the surface-drainage network.
- (h) Report in preparation.
- (3961) USE OF WATER BY SALT CEDAR.
- (b) Bureau of Reclamation.
- (c) Dr. T. E. A. vanHylickama, USGS, Phoenix, Arizona.
- (e) The purpose of this project is to measure the use of ground water by salt cedar in evapotranspirometers and to evaluate these data against those obtained by energy budget and mass transfer methods. Estimates can then be made of the quantity of water salvageable by control or eradication of salt cedar. Large evapotranspirometers have been constructed in an environment of salt cedar and planted at the same density as in the surrounding area. The use of water from these tanks will be measured and the effect of maintaining ground water at different levels studied.
- (g) Additional work to record growth by measurement and analytical illustrations of seedling and frond development was started during the 1961 season. Growth will be correlated with water use. A progress report dealing with water budget findings through 1961 is in preparation.
- (3962) RESEARCH IN PHREATOPHYTES.
- (b) Laboratory project.
- (c) Mr. T. W. Robinson, USGS, Menlo Park, Calif.
- (d) Field investigation.
- (e) The purpose of this project is to estimate with reasonable accuracy the quantity and quality of the ground water consumptively wasted and to evaluate the quantity and quality of the water that can be salvaged by control or eradication of the phreatophyte. The fields of study involved in attaining these objectives are: (1) A knowledge of the habitats and life-cycle characteristics of problem phreatophytes; (2) the factors that control their growth, development, and occurrence; (3) the factors that affect their use of ground water; and (4) economic methods for effecting salvage of the water consumptively wasted by phreatophytes. Among others, data are needed on occurrence, which requires mapping of areas and density of growth; relations of occurrence to the quality of the ground water; depth of root penetration; effects of phreatophytes on flood-plain erosion and sedimentary processes; and the annual water consumption for different depths to the water table under different climatic conditions, by species.
- (h) "A Guide to Mapping Phreatophytes," by J. S. Horton, U.S. Forest Service, T. W. Robinson, U.S. Geological Survey, and H. A. McDonald, U.S. Bureau of Reclamation, being reviewed for publication. A salt cedar map is in preparation.
- (3963) EVAPOTRANSPIRATION THEORY AND MEASUREMENT.
- (b) Laboratory project.
- (c) Mr. O. E. Leppanen, USGS, Phoenix, Arizona.
- (d) Field investigation.
- (e) The purpose of this project is to study the physical processes involved in evapotranspiration and to develop techniques and equipment for measuring evapotranspiration. The studies encompass an analysis of the physical forces and differential equations describing the transport of momentum, latent heat of evaporation, energy, water vapor, and possibly carbon dioxide in the earth's surface in order to develop practical techniques and instruments for the measurement of evapotranspiration.
- (g) Final report in preparation.
- (3964) MECHANICS OF EVAPORATION.
- (b) Laboratory project.
- (c) Mr. J. S. Meyers, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to find ways of simplifying and reducing the costs of data collection for the energy-budget method of evaporation determination. This method has proven to be accurate and reliable. However, it is costly and much simplification is needed before it can be widely used to determine evaporation either from free water surfaces or from bare land surfaces. Data processing has been another costly item; however, the use of high-speed computing machines are expected to reduce this somewhat after more reliability is built into the field-recording systems. The possibility of using available Weather Bureau data will be explored.
- (g) The energy-budget method of evaporation determination has been developed and has proven much more accurate than the old evaporation pan method. Much remains to be done.
- (h) "A Practical Field Technique for Measuring Reservoir Evaporation Utilizing Mass-Transfer Theory," by G. E. Harbeck, Jr., U.S. Geol. Survey Professional Paper 272-E is being processed.
- (3965) HYDROLOGIC EFFECT OF VEGETATION MODIFICATION.
- (b) Laboratory project.
- (c) Mr. R. C. Culler, USGS, Tucson, Arizona.
- (d) Field investigation.

- (e) The purpose of this project is to evaluate the change in water yield produced by the vegetation modification and to develop a more comprehensible understanding of the function of vegetation, within the hydrologic regime, under semiarid conditions. Substitution of short-rooted grass for deep-rooted trees is the basis for this study. The study has been divided into two parts; (1) The determination of the changes in water yield produced by a pinon-juniper eradication program on a drainage area of 200 square miles; and (2) the intensive study of 2 pairs of small watersheds to evaluate the hydrologic processes involved and alterations that occur as a result of vegetation modification. Correlations of runoff, using precipitation will be used for (1). In part (2) an attempt will be made to evaluate the major portions of the hydrologic cycle and to define the inter-relationships. Study site is Carrizo and Corduroy Creek basins in the Fort Apache Indian Reservation, Arizona.
- (g) Six gaging stations were constructed. The Bureau of Indian Affairs has cleared Corduroy Basin of pinon-juniper, and correlations are being computed.
- (h) "Soil Moisture Under Juniper and Pinyon Compared with Moisture Under Grassland in Arizona," by R. F. Miller, F. A. Branson, I. S. McQueen, and R. C. Culler, U. S. Geol. Survey Prof. Paper 424-B, Article 98, 1961. "Description of the Juniper and Pinyon Eradication Project, Fort Apache Indian Reservation, Arizona," by R. C. Culler, is being processed for publication as U. S. Geological Survey Circular. Progress report on findings through 1961 in preparation.
- (3966) EFFECTS OF SEDIMENT CHARACTERISTICS OF FLUVIAL MORPHOLOGY AND HYDRAULICS.
- (b) Laboratory project.
- (c) Dr. S. A. Schumm, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to collect data on the physical properties of sediments forming the perimeter of alluvial channels, and to determine the effect of sediment type on fluvial morphology and hydraulics. The physical and chemical properties of alluvial materials and their relations to and effects upon fluvial morphology are not well enough understood and require considerable research. Basic data are collected at about 200 cross-sectional sites on as many as possible of the following: channel shape, dimensions, gradient, pattern, and roughness; channel and bank vegetation; stream discharge; velocity of flow; suspended and bed sediment loads; and the types of sediment forming the cross-sectional perimeter of the channels.
- (h) "Dimensions of Some Stable Alluvial Channels," by S. A. Schumm, U. S. Geological Survey Prof. Paper 424-B, Article 13, 1961. "Channel Widening and Flood-Plain Construction Along Cimarron River in Western Kansas," by S. A. Schumm and R. W. Lichty, U. S. Geol. Survey Prof. Paper 352-D, in review.
- (3967) STUDY OF AGGRADATION AND DEGRADATION IN STREAM CHANNELS.
- (b) Laboratory project.
- (c) Dr. S. A. Schumm, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to study the mechanics of channel formation in alluvium of semiarid and arid valleys, and sediment deposition in ephemeral stream channels. The physical properties of alluvial materials have not been related satisfactorily to stream channel characteristics. This project involves the relation of sediment types to channel pattern, longitudinal profile, channel shape and roughness, bed-load movement, and variations in discharge, and takes place in several areas in Colorado, Wyoming, Kansas and Nebraska.
- (f) Completed.
- (h) "The Effect of Sediment Type on the Shape and Stratification of Some Modern Fluvial Deposits," by S. A. Schumm, American Jour. of Science, Vol. 258, p. 177-184, 1960. "The Shape of Alluvial Channels in Relation to Sediment Type," by S. A. Schumm, U. S. Geological Survey Prof. Paper 352-B, p. 17-30, 1960. "The Effect of Sediment Type on the Shape and Stratification of Some Modern Fluvial Deposits: A Reply," by S. A. Schumm, American Journal of Science, Vol. 259, p. 234-239, 1961. "Effect of Sediment Characteristics on Erosion and Deposition in Ephemeral-Stream Channels," by S. A. Schumm, U. S. Geological Survey Prof. Paper 352-C, p. 21-70, 1961.
- (3968) STUDY OF CHANNEL CHARACTERISTICS AND FLOOD-PLAIN AGGRADATION, TUSAYAN WASHES, ARIZONA.
- (b) Laboratory project.
- (c) Mr. R. F. Hadley, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to determine the physical and hydraulic factors that control channel characteristics in aggrading and degrading alluvial channels in the semiarid and arid Southwest. An understanding of these processes is needed in order to plan conservation practices in a logical and economic fashion. The project includes study of aggradation occurring naturally as well as aggradation induced by channel structures. Studies are in the drainage basins of Polacca, Oraibi, Jeddito, Dinnebito Washes, all tributary to Little Colorado River near Winslow in northeastern Arizona.
- (g) Report in preparation.
- (3969) GENERAL STUDIES OF EROSION AND SEDIMENTATION.
- (b) Laboratory project.
- (c) Mr. R. F. Hadley and Mr. N. J. King, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to investigate the basic processes of erosion in a semiarid and arid environment. Studies fall into three general groups: (1) Quantitative measurements of gully growth, channel widening, and channel erosion; (2) measurements of rates of upland erosion; and (3) detailed studies of a particular erosion process in a selected area. The quantitative measurements will be utilized to aid in design of soil and water conservation measures. Studies are being made in several areas in Montana, Wyoming, Utah, New Mexico, and Arizona.
- (h) "An Example of Channel Aggradation Induced by Flood Control," by N. J. King, U. S. Geol. Survey Professional Paper 424-B, Article 15, 1961. "Some Factors Influencing Streambank Erodibility," by I. S. McQueen, U. S. Geol. Survey Professional Paper 424-B, Article 14, 1961.
- (3970) HYDROLOGIC EFFECTS OF URBANIZATION.
- (b) Laboratory project.
- (c) Mr. A. O. Waananen, USGS, Menlo Park, Calif.
- (d) Field investigation.
- (e) The purpose of this project is to evaluate the hydrologic effects of changes in land use associated with development of suburban, industrial and urban communities; also included is a study of hydrologic problems in storm drainage in urban areas. Changes in land use associated with urban development affect local hydrologic factors such as runoff, flood frequency, recharge, channel stability, sediment production and the inter-relationship between surface and ground

- water. Data on stream flow, precipitation, soil moisture and related hydrologic and climatologic data, topographic effects, and geologic, soils, and ecologic information, together with documentation of changes in land use as they occur, are needed for proper evaluation. The study area, San Francisquito Basin at Stanford University, Palo Alto, California.
- (h) Reports in preparation: (1) "Effect of Urban Development on Storm Runoff," and (2) "San Francisquito Urbanization Project - Natural Environment."
- (3971) THE HYDROLOGY OF PRAIRIE POTHOLE, NORTH DAKOTA.
- (b) Laboratory project.
- (c) Mr. Wm. S. Eisenlohr, Jr., USGS, Denver, Colo., and Mr. J. B. Shjeflo, USGS, Bismarck, N. Dak.
- (d) Field investigation; applied research.
- (e) To determine use of water in prairie potholes (kettles) in glaciated areas in North Dakota. The potholes are important in wildlife production, especially migratory ducks. Plans for irrigation developments, involving about a million acres in North and South Dakota, would require the draining and leveling of many potholes. Information is being collected to estimate the hydrologic effects of these proposed changes as well as the amount of water required to provide replacement water areas for wildlife production. Study includes observations necessary to determine the water budget and the type, amount, and rates of growth of vegetation.
- (g) Two groups of four potholes were selected and instruments installed. One pothole in each group is clear of vegetation. As a result of drought in 1961, five of the potholes went dry, some for the first time in more than 25 years according to residents. The first complete season of data were collected.
- (3972) STUDY OF WATER APPLICATION AND USE ON A RANGE WATERSPREADER IN NORTHEASTERN MONTANA.
- (b) Laboratory project.
- (c) Dr. F. A. Branson, Mr. I. S. McQueen, and Mr. R. F. Miller, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to evaluate the use of a waterspreader on forage yields. Little information is available on amounts of water applied to and used by waterspreaders or on the amounts of water needed for successful waterspreaders. As water becomes more in demand, information on the efficiency of water used by waterspreaders becomes increasingly important. Water applied to the spreader is measured by means of a water-stage recorder which determines the duration of flow through a pipe into the spreader and by means of a rain gage. Plant measurements are being made by the Montana Agricultural Experiment Station. Study site is the Willow Creek area near Fort Peck, Mont.
- (g) Data on soil moisture storage and use have been obtained for three years (1959-61) when water was applied to the spreader. Analyses are being made of the differences in storage and use on the three major soil-vegetation types included in the spreader.
- (3973) STUDY OF PRECIPITATION, RUNOFF, AND SEDIMENT YIELD IN CORNFIELD WASH, NEW MEXICO.
- (b) Laboratory project.
- (c) Mr. Durl E. Burkham, USGS, Albuquerque, New Mexico.
- (d) Field investigation.
- (e) The purpose of this project is to obtain hydrologic data for use in the design of soil and water conservation structures and to evaluate the effects of structures on control of flood runoff and erosion. The original study was started in 1951 when the Bureau of Land Management completed construction of reservoirs in an area about 15 miles southwest of Cuba, New Mexico. In the fall of 1957 part of the watersheds were pitted by a mechanical pitter in an attempt to increase infiltration and growth of vegetation.
- (f) Intensive field investigation completed in 1960 after a 10-year study. Further studies will be limited mainly to resurveys of erosion or sediment deposition.
- (g) A report presenting results of the 10-year study (1951-60) is in preparation.
- (h) "Water-Supply Paper 1475-B," reports the results of the first five years, 1951-55.
- (3974) LABORATORY STUDY OF THE GORWTH OF MEANDERS IN OPEN CHANNELS.
- (b) Laboratory project.
- (c) Dr. M. G. Wolman and Mr. Michael Moore, Johns Hopkins University, Baltimore, Md.
- (e) The purpose of this project is to attempt to establish channels having various initial ratios of width to curvature. Each channel pattern will be allowed to develop under controlled conditions of slope and discharge, and the rate of growth and change in pattern will be observed continuously. This study is a continuation of the work begun in the experiments by Leopold, Bagnold, Wolman, and Brush and deal with the energy losses and behavior of curved channels.
- (3975) STUDY OF EFFECTS OF GRAZING IN BADGER WASH AREA, COLORADO.
- (b) Laboratory project.
- (c) Mr. G. C. Lusby, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to determine the effects of grazing exclusion in regard to improving vegetation, and reducing damaging floods, upstream erosion and downstream sedimentation. This study was planned and started in 1953 as a cooperative undertaking between the Bureau of Land Management, Forest Service, Bureau of Reclamation, and the Survey. Studies by the Fish and Wildlife Service started a year later. The study by agreement is to run for 20 years. Twenty reservoirs were constructed and records of runoff and sediment are collected on each. The study area is divided into four pairs of areas each with a dam and reservoir. One of each pair is fenced to exclude grazing and the other is left open. Study area is about 8 miles northwest of Mack, Mesa County, Colorado.
- (g) Progress report presenting results of first 5 years of study (1954-58) in review.
- (h) "Hydrology of Small Grazed and Ungrazed Drainage Basin, Badger Wash Area, Western Colorado," by Gregg C. Lusby, U. S. Geol. Survey Prof. Paper 424-B, Article 59, 1961.
- (3976) EVALUATION OF SEDIMENT BARRIER ON SHEEP CREEK, NEAR TROPIC, UTAH.
- (b) Laboratory project.
- (c) Mr. G. C. Lusby, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this study is to test the effectiveness of treatment methods to reduce the high sediment contribution of the Paria River and similar streams. In addition to land-treatment practices, which will be carried out by the Forest Service, National Park Service, Bureau of Land Management and Soil Conservation Service, the Bureau of Reclamation has constructed a small barrier on Sheep Creek. The Survey is to measure the effect of this barrier on runoff and sediment at a site about 7 miles southwest of Tropic, Utah.
- (g) A dam was constructed on Sheep Creek in 1960 and sediment samplers were installed in the channel upstream from the dam and in the

spillway. Runoff during the 1960 water year was very low, but in 1961 runoff occurred several times in relatively large amounts. Sediment deposition in the reservoir and channel upstream in 1961 was appreciable.

(3977) HYDROLOGIC EFFECTS OF SMALL RESERVOIRS.

- (b) Laboratory project.
- (c) Mr. F. W. Kennon and Mr. R. W. Stallman, USGS, Oklahoma City 2, Oklahoma.
- (d) Field investigation.
- (e) During recent years there has been a great increase in the number of small reservoirs being constructed for stock water supply, irrigation, flood control, recreation, and other uses. The purpose of this project is to evaluate this type of construction in terms of its effect on the hydrology of the area. Similar work has been done in other parts of the West.
- (h) "Hydrologic Studies of Small Watersheds, Honey Creek Basin, Texas," by C. R. Gilbert, G.E. Koberg, and F.W. Kennon, being reviewed for publication.
"Hydrologic Effects of Small Reservoirs, Water Years 959-60, Sandstone Creek, Oklahoma," by F. W. Kennon, in preparation.
"Hydrologic Effects of Small Reservoirs, Deep Creek, Texas," in preparation.
"The Use of Temperature Data for Computing Ground-Water Velocity (on the Basis of Data Collected in the Sandstone Creek Area)," by R. A. McCullough, in preparation.

(3978) EFFECTS OF MECHANICAL TREATMENTS ON ARID LANDS IN WESTERN UNITED STATES.

- (b) Laboratory project.
- (c) Mr. A. Branson, Mr. I. S. McQueen, and Mr. R. F. Miller, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to determine the effects of different mechanical treatments on arid lands. Several small basins on land administered by the Bureau of Land Management in central Montana, eastern New Mexico, and western Colorado, are the study sites. Some reservoirs have been, and others are to be constructed in each of these basins, and runoff and sediment yield is being and has been determined before treatments are applied. Among the treatments applied after precalibration are the following: spike-tooth pitting, eccentric-disc pitting, and contour furrowing (with furrow intervals determined on the basis of computed furrow water-storage capacity). Other measurements made would include: vegetation kinds and quantities before and after treatment, soil-moisture storage and seasonal and annual changes.
- (h) "Effects of Contour Furrowing, Grazing Intensity and Soils on Infiltration Rates, Soil Moisture and Vegetation near Fort Peck, Montana," by F. A. Branson, R. F. Miller, and I. S. McQueen, being reviewed for publication.

(3979) GENERAL EVALUATION OF SOIL AND MOISTURE TREATMENT PRACTICES.

- (b) Laboratory investigation.
- (c) Mr. K. R. Melin, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to appraise the structures and treatment practices used in soil moisture conservation to determine their effectiveness in accomplishing the purposes for which they were designed. The field studies include maintenance of records on runoff, erosion and sedimentation to determine the effects of the structures or practices at several areas in Colorado, Utah, Arizona, Wyoming, Montana, and New Mexico.

(3980) HYDROLOGY OF DEATH VALLEY.

- (b) Laboratory project.
- (c) Mr. T. W. Robinson and Mr. C. B. Hunt, USGS, Menlo Park, California.
- (d) Field investigation.
- (e) The purpose of this report is to study the various phases of the hydrology of Death Valley. Data on evaporation, wind movement, humidity and temperature are being obtained under informal agreement with the National Park Service. Relations of plants to salinity and effects of salinity on evapotranspiration also are being investigated.
- (h) "Some Extremes of Climate in Death Valley, California," by T. W. Robinson and C. B. Hunt, U. S. Geological Survey Professional Paper 424-B, Article 79, 1961.

(3981) PLEISTOCENE LAKES OF THE GREAT BASIN.

- (b) Nevada State Engineers.
- (c) Mr. C. T. Snyder, USGS, Menlo Park, Calif.
- (d) Field investigation.
- (e) The purpose of this project is to prepare a map based on data gathered during Soil and Moisture Conservation investigations showing the Pleistocene Lakes in the Great Basin area. Further refinements can now be made to Lakes Lahounta and Bonneville and the associated smaller lakes that existed concurrently. An additional large Pleistocene lake recently discovered is included.
- (g) Map and report in preparation.

(3982) INTERRELATIONSHIPS BETWEEN ION DISTRIBUTION AND WATER MOVEMENT IN SOILS AND THE ASSOCIATED VEGETATION.

- (b) Laboratory project.
- (c) Mr. R. F. Miller, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this study is to obtain information basic to improvement of water use and vegetation yields on arid lands. These data are needed to evaluate the potential of treatment practices proposed on an extensive scale on the public domain. This study emphasizes the investigation of soil chemistry as it affects the swelling or shrinkage of soils and may have as great an effect of hydrologic characteristics as texture. Study areas are in several locations on public lands in several western states.
- (g) Field work on this project largely completed; laboratory work partially completed; data evaluation and preparation of reports in progress.
- (h) "Water Movement and Ion Distribution in Soils," by R. F. Miller and K. W. Ratzlaff, U. S. Geological Survey Paper 424-B, Article 22, 1961.

(3983) DEVELOPMENT OF FIELD CRITERIA FOR EVALUATING SITES FOR FLOOD WATER SPREADING.

- (b) Laboratory project.
- (c) Mr. R. F. Miller, USGS, Denver, Colo.
- (d) Field investigation.
- (e) The purpose of this project is to determine field criteria with which to evaluate potential sites before making relatively large expenditures for further developments. Examinations made to date on spreaders in several localities suggest that in addition to adequacy of water available the infiltration characteristics and moisture-holding capacity of the soils are important factors. The kinds and quantities of vegetation growing where water collects naturally on similar soils on or near proposed sites may be a useful indicator of the potentiality of the site after water is applied.
- (g) Field sampling of existing waterspreaders in Montana, Wyoming, Colorado, and New Mexico, in progress; laboratory analyses in progress.

(3984) WATER AND SOIL RELATIONSHIPS AS INDICATED BY PLANT SPECIES OR PLANT COMMUNITIES.

- (b) Laboratory project.
 - (c) Dr. F. A. Branson, Mr. I. S. McQueen and Mr. R. F. Miller, USGS, Denver, Colo.
 - (d) Field investigation.
 - (e) The purpose of this project is to determine whether or not phonological development of vegetation differs for communities having the same macroclimate but different soils. Plants have been used as indicators of conditions, processes and uses for many years. Where plants can be used as indicators of soil conditions, expensive measurements of physical and chemical properties can be reduced. Plant species or communities may be used as indicators of potential production to be expected from land management and treatment practices. Research sites are near Golden, Colorado. Other sites will be selected.
 - (g) Preliminary work and some mapping has been accomplished.
 - (h) "Soil-Moisture Storage Characteristics and Infiltration Rates as Indicated by Annual Grasslands near Palo Alto, California," by F.A. Branson, R.F. Miller, and I.S. McQueen, U. S. Geological Survey Professional Paper 424-B, Article 76, 1961.
"Soil-Water Availability and Use by Grasslands on Adjacent Stony and Shale-Derived Soils in Colorado," by F. A. Branson, R. F. Miller, and I. S. McQueen, U. S. Geological Survey Professional Paper 424-C, being processed for publication.
- (4404) EROSION, SEDIMENTATION, AND LAND-FORM DEVELOPMENT IN ARID AND SEMIARID REGIONS.
- (b) Laboratory project.
 - (c) Messrs. Gerald G. Parker, Reuben C. Miller, and Irel S. McQueen, USGS, Denver, Colo.
 - (d) Field investigation; both basic and applied research.
 - (e) Purpose is to ascertain the causes and forces that separate soil and/or rock particles from their sources, and to study the resultant land forms for geomorphic analyses. Field study areas have been selected in several western States, and a primary field research station has been established at the Warbonnet Ranch, 13 miles north of Harrison, Nebr., where all factors relating to erosion and sedimentation are being measured both automatically by specialized recording instruments and manually. The Warbonnet research station has been established for a minimum 10-year project life.
- (4405) PIPING, AN EROSIONAL PHENOMENON IN CERTAIN SILTY SOILS OF ARID AND SEMIARID REGIONS.
- (b) Laboratory project.
 - (c) Messrs. Gerald G. Parker, Reuben C. Miller, and Irel S. McQueen, USGS, Denver, Colo.
 - (d) Field investigation; both basic and applied research.
 - (e) Purpose is to ascertain the causes of piping and thus enable field engineers and geologists to control this form of destructive erosion. Soils chemistry and physiology will be thoroughly investigated, the atmospheric and other environmental factors related to piping will be determined, and long-term (10 years, at least) observational records will be kept on several areas where piping is a prominent form of erosion. Primary study areas are near Chinle and Cameron in Arizona; Cuba, New Mexico; and Panquitch, Utah.
- (4406) TECHNIQUES FOR UTILIZATION OF SEDIMENT RECONNAISSANCE DATA.
- (b) Laboratory project.
 - (c) Mr. H. P. Guy, USGS, Washington 25, D.C.
 - (d) Theoretical analyses; applied research.
 - (e) Examination of quantitative relationships between sediment yield and environment for basin and regions in eastern United States and development of techniques for translating minimum, pertinent sediment observations into an adequate quantitative description of sediment behavior in selected basins.
- (h) Progress report in preparation.
- (4407) THE EFFECT OF WAVES ON PIEZOMETER REGISTRATION.
- (b) Laboratory project.
 - (c) Prof. C. E. Kindsvater, Georgia Institute of Technology, Atlanta, Georgia.
 - (d) Experimental; applied research for a master's thesis.
 - (e) To determine the reliability of depth of flow as measured with piezometers. Determine effects of waves with a range of flow depths, velocities and different piezometer installations.
 - (f) Completed.
 - (g) The effect of piezometer size is a positive piezometric error, which increased with piezometer diameter, depth of flow, and Froude number. Within the scope of the tests, piezometric measurements were not influenced by surface waves.
 - (h) "Piezometric Measurement of Depth in Open Channels," by W. W. Emmett, 1961, M. S. Thesis, Georgia Institute of Technology.
"Influence of Piezometer Hole Diameter on Depth Determinations in a Smooth Open Channel," by W. W. Emmett, in Geological Survey Research 1961: U. S. Geol. Survey Prof. Paper 424-C.
- (4408) ANALOG MODELS OF HYDROLOGIC PHENOMENA.
- (b) Laboratory project.
 - (c) Mr. John Shen, USGS, Phoenix, Arizona.
 - (d) Basic and applied research.
 - (e) Investigation of applicability of analog computer technique to solve problems involving either hydrologic data in general or surface-water flow in particular.
 - (g) Methods and instrumentation being investigated.
- (4409) TURBULENT DIFFUSION IN OPEN CHANNELS.
- (b) Laboratory project.
 - (c) Mr. R. W. Carter, USGS, Washington 25, D.C.
 - (d) Experimental, theoretical; basic research.
 - (e) Develop necessary instrumentation; compare Eulerian and Lagrangian methods of expressing the flow field; observe effects of boundary roughness, channel geometry, and flow conditions on turbulent field; and define the relations of the turbulence spectrum and diffusion patterns.
 - (g) Instrumentation being developed.
- (4410) BANK SEEPAGE DURING FLOOD FLOWS.
- (b) Laboratory project.
 - (c) Mr. M. R. Williams, USGS, Washington 25, D.C.
 - (d) Field investigation; applied research for doctoral thesis.
 - (e) Purpose is to understand the mechanics of seepage flow into and from bank storage along a channel in response to movement of flood waves through a channel reach.
 - (g) Doctoral thesis to be prepared by Mr. E. G. Pogge at University of Iowa, Iowa City, Iowa.
- (4411) LIQUID MOVEMENT IN CLAYS.
- (b) Laboratory project.
 - (c) Dr. H. W. Olsen, USGS, Washington 25, D.C.
 - (d) Experimental and theoretical study; basic research.
 - (e) To study the nature of liquid movement through clays in response to gradients of electrical potential, ionic concentration, and temperature; and to relate the movement to such factors as the mineralogical and chemical composition of the clay and pore liquid.

(4436) FLOW PROPERTIES OF COAL-WATER SLURRIES.

- (b) Laboratory project--information for general public use.
- (c) Dr. L. L. Hirst, Research Director, Morgantown Coal Research Center, Morgantown, West Virginia.
- (d) Experimental; applied research.
- (e) The object of the project is to establish friction factor-Reynolds number relationships for coal-water slurries of various concentrations with coals of different ranks and size analyses. Work is being done with 1/2 inch, 3/4 inch, and 1 inch pipes. Data are processed on an IBM-1620 computer.
- (g) Preliminary results show a change in rheological classification at or above 45 percent coal concentrations.
- (h) "Metering Density and Flow in 1:1 Coal Slurry," by W. R. Huff and L. F. Willmott, Chemical Processing, vol. 24, No. 2, Feb. 1961, pp. 61-62.
"Bibliography of Technical References to Aqueous Slurries of Granular Materials: With Special Reference to the Rheology of Coal-Water Slurries," by L. F. Willmott, W. R. Huff, and W. E. Crockett, Bureau of Mines Inf. Circ. (in process of publication, 1962).

U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION.

Inquiries concerning the following projects should be addressed to Assistant Commissioner and Chief Engineer, Bureau of Reclamation, Denver Federal Center, Denver 25, Colorado.

(1502) STABLE CHANNEL STUDIES--TRACTION FORCES REQUIRED TO MOVE NONCOHESIVE MATERIALS.

- (f) Tests completed.
- (h) "Traction Force Distributions Around the Perimeter of an Open Channel by Point Velocity Measurement," Thesis by Phillip F. Enger, University of Colorado, August 1960.
"Traction Force Fluctuations Around an Open Channel Perimeter as Determined from Point Velocity Measurements," by Phillip F. Enger, paper presented at ASCE Convention, Phoenix, Arizona, 1961.

(1777) SIPHON SPILLWAY STUDIES.

- (f) Suspended.

(2457) EROSION AND TRACTIVE FORCE STUDY OF UNLINED AND EARTH-LINED CANALS.

- (e) Three field test reaches have been selected for study and for verification of laboratory studies in order to establish critical tractive force criteria for design of canals. A laboratory flume is being calibrated for determining tractive forces that erode soil in terms of standard soil properties.
- (h) "Use of an Electronic Computer to Analyze Data from Studies of Critical Tractive Forces for Cohesive Soils," by C. W. Thomas and P. F. Enger, IAHR, Ninth Convention, Dubrovnik, Yugoslavia, 1961.

(2719) GLEN CANYON DAM SPILLWAY.

- (f) Tests completed.
- (h) Report in preparation.

(2953) STUDIES OF WIND WAVES ON CANALS.

- (f) Field data are being analyzed.
- (g) Waves have been measured on field canals, and wave characteristics have been correlated with canal characteristics and wind velocity and direction.
- (h) "Progress Report 1--Canal Bank Erosion Due

to Wind-Generated Water Waves," by E. J. Carlson and W. W. Sayer, Report No. HYD-466, January 1961 (other reports in preparation).

(2955) CAVITATION IN SUDDEN ENLARGEMENTS DOWN-STREAM FROM GATE VALVES.

- (f) Suspended.

(2959) STILLING BASINS FOR SLIDE GATE CONTROLLED OUTLET WORKS.

- (f) Tests in progress.
- (h) Report to be prepared.

(2960) FLAMING GORGE DAM SPILLWAY.

- (f) Tests completed.
- (h) Report in preparation.

(3267) CANAL INLET AND OUTLET TRANSITION STUDIES.

- (f) Tests continuing.
- (g) Losses for a variety of conventional, open, broken-back transitions were found to be 0.6 to 0.7 Δh_v for outlet service and 0.4 Δh_v for inlet service. Losses for structures using simple closed conduit transitions were about 0.1 Δh_v and 0.4 Δh_v respectively. Scour was slightly reduced with the closed conduit transitions.
- (h) Progress report in preparation.

(3270) SAN ACACIA DIVERSION--HEADWORKS AND SLUICeway

- (f) Tests completed.
- (h) Report in preparation.

(3271) CHANNELIZATION IN ALLUVIAL RIVERS USING STEEL JACKS AND JETTIES.

- (f) Laboratory tests completed, field data to be analyzed progressively as obtained.
- (h) "Hydraulic Model and Prototype Studies of Casa Colorado Channelization--Middle Rio Grande Project, New Mexico," by R. A. Dodge, Jr., Report No. HYD-477.

(3272) NAVAJO DAM SPILLWAY AND AUXILIARY OUTLET WORKS.

- (f) Completed.
- (h) "Hydraulic Model Studies of Navajo Dam Spillway and Auxiliary Outlet Works Junction with the Spillway," by G. L. Beichley, Report No. HYD-458, November 1961.

(3274) CONSTANT HEAD ORIFICE TURNOUT.

- (f) Tests completed.
- (h) Report in preparation.

(3275) FRICTION FACTOR TESTS IN LARGE PRESSURE CONDUITS--EKLUTNA TUNNEL, ALASKA.

- (f) Tests and data analyses completed.
- (h) Report on second set of tests in preparation.

(3278) CAVITATION OF CONCRETE SURFACE IRREGULARITIES

- (h) Additional reports to be prepared.

(3609) TWIN BUTTES OUTLET WORKS INTAKE STRUCTURES.

- (f) Completed.
- (h) Report in preparation.

(3611) ADJUSTABLE WEIR.

- (f) Single weir investigation completed.
- (h) Report in preparation.

(3612) DISCHARGE COEFFICIENTS FOR RADIAL GATES.

- (b) Laboratory project.
- (d) Experimental, laboratory and field investigations; applied research.
- (e) Radial gates are used extensively in irrigation systems for discharge and water sur-

face level control. Intelligent operation of the systems requires that the rate of flow passing the gated structure be known. Literature research resulted in an analytical approach and adjusted equation for the gate capacity with unsubmerged flow. A model gate was designed and will be installed in the laboratory to obtain data for checking the proposed formula and extending the scope of presently available information.

(3613) COMPOUND WEIR STUDIES.

- (f) Tests completed.
- (h) Report in preparation.

(3614) EXPERIMENTAL STUDY OF SUBCRITICAL FLOW IN CURVED CHANNELS.

- (b) Laboratory project.
- (d) Experimental; applied research and design.
- (e) A fixed-bed, hydraulic model has been constructed to determine the possibility of reduction in scour and deposition in unlined channels due to secondary currents. Preliminary investigations will be conducted by varying the radius of curvature and the central angle.
- (f) Tests in progress.

(3985) DISCHARGE CAPACITY OF LARGE CONCRETE-LINED CANALS.

- (b) Laboratory project.
- (d) Experimental, laboratory and field investigations; applied research and design.
- (e) This study is for the purpose of exploring the effects on the hydraulic gradient of the relationship of boundary surface resistance to the cumulative resistance of crossings, inlets, turnouts, checks, and other local items in concrete-lined canals of different sizes, shapes and grades. This study is part of a program to explain why design procedures used successfully for small and medium sizes of canals may not be adequate for large concrete-lined canals on flat slopes.

(3986) MERRITT DAM CANAL OUTLET WORKS.

- (f) Completed.
- (h) "Hydraulic Model Studies of Merritt Dam Canal Outlet Works," by G. L. Beichley, Report No. HYD-456, August 1961.

(3987) HIGHWAY RUNDOWN DRAIN.

- (f) Tests completed.
- (h) Test results have been furnished to Bureau of Public Roads, who will prepare report.

(3988) YELLOWTAIL DAM OUTLET WORKS.

- (f) Tests completed.
- (g) A satisfactory structure was developed that provided good operation over the full range of extreme tail water variations.
- (h) Report in preparation.

(3989) YELLOWTAIL DAM SPILLWAY.

- (f) Completed.
- (g) The following were developed during the study: width and alignment of the approach channel; length and shape of the pier at the gate section; discharge calibration; curvature of the tunnel trajectory approaching the combination flip bucket stilling basin; length, depth, and shape of the flip bucket basin; and riprap requirements downstream from basin.

(3990) BAFFLED APRON FOR GRAVITY FLOW BYPASS--WILLARD CANAL PUMPING PLANT NO. 1.

- (f) Tests completed.
- (g) Previous tests have shown that for satisfactory operation of an apron on a 2:1 slope with baffle piers 3 feet high, the spacing of

the rows should be 6 feet measured along the slopes. Tests conducted on drops with slopes of 3:1 and 4-1/2:1 showed that the vertical fall distance between rows of baffle piers is constant, thus allowing greater spacing between rows of piers for aprons on flatter slopes.

- (h) Report in preparation.

(3991) SEDIMENT TESTS ON PROTOTYPE DIVERSION DAMS--KANSAS RIVER BASIN--NEBRASKA-KANSAS.

- (f) Data obtained in the field have been partially analyzed.
- (h) Report in preparation.

(3994) HYDRAULIC JUMP CHUTE BLOCK AND BAFFLE BLOCK PRESSURES.

- (f) Tests in progress.
- (g) Thus far, the minimum subatmospheric pressures on a square-edged chute block whose height and width are equal to the depth of the approaching flow is related to tail water depth for a range of approach velocities.

(3995) LABORATORY STUDY TO DETERMINE THE EQUILIBRIUM BEACH PROFILE FOR FIGARDEN RESERVOIR SITE--CENTRAL VALLEY PROJECT, CALIFORNIA.

- (f) Tests completed.
- (h) Report in preparation.

(3996) HIGH HEAD ORIFICE STUDIES.

- (f) Tests in progress.
- (h) Report to be prepared.

(3997) TWIN BUTTES AUXILIARY OUTLET GATES.

- (f) Completed.
- (g) An elliptical bellmouth entrance of the form

$$\frac{x^2}{D^2} + \frac{y^2}{(D/3)^2} = 1$$

results in satisfactory pressures for this application. The discharge coefficient, based on the maximum gate opening and total reservoir head, was 0.93.

- (h) "Hydraulic Model Studies of the 2- by 2-foot Twin Buttes Regulating Gate--San Angelo Project, Texas," by H. T. Falvey, Report No. HYD-476, January 1961.

(3998) JET FLOW GATE--TRINITY DAM.

- (f) Completed.
- (g) The newer design jet flow gate performed well and had a 0.833 discharge coefficient based on orifice area and upstream total head minus downstream pressure head. Air demand-versus-Froude number minus 1 conformed to Kalinske and Robertson data.
- (h) "Hydraulic Model Studies of the Trinity Dam Auxiliary Outlet Works Jet Flow Gate--Central Valley Project, California," by W.P. Simmons, Jr., Report No. HYD-472, January 1961.

(4412) OROVILLE DAM DIVERSION TUNNELS AND TAILRACE.

- (b) California Department of Water Resources.
- (d) Experimental, for design.
- (e) A 1:54.63 scale hydraulic model will be used to study complex, high-velocity diversion flows in the two 35-foot-diameter, 4,500-foot long tunnels; and to study surge characteristics of the underground powerhouse whose draft tubes connect to the downstream portion of the tunnels to form the tailrace. A 1:46.6 scale air model will be used to evaluate various passage configurations for connecting the draft tubes to the tunnels to obtain minimum losses.
- (f) Models being constructed.

(4413) OROVILLE DAM TUNNEL PLUG OUTLET WORKS.

- (b) California Department of Water Resources.
(d) Experimental, for design.
(e) A 1:18 scale model of the tunnel plug outlet works was constructed to determine the appurtenant structures necessary in the 35-foot-diameter tunnel to adequately dissipate the high energy flow from two 54-inch Howell-Bunger valves discharging under a 670-foot head.
- (4414) WANSHP DAM VERTICAL STILLING WELLS.
(b) Laboratory project.
(d) Experimental; applied research and design.
(e) Laboratory tests were made to determine the required depth of two vertical stilling wells having corner fillets and a sleeve-type valve which seats on a pedestal in the center of the well floor.
(g) A water depth of 9.3 feet is sufficient to produce a smooth water surface in a well 6 by 6 feet, operating at a maximum design discharge of 16.7 cubic feet per second under total design heads up to 118 feet. A water depth of 11.8 feet is required in the same size well without corner fillets. Water depths and heads are measured from the top of the pedestal.
(h) Report in preparation.
- (4415) FISH PROTECTIVE FACILITIES--TRACY PUMPING PLANT.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:6.3 scale model was used to determine modifications for the existing secondary fish screen structure to eliminate the large-scale turbulences and eddies which produced unnecessary fish mortalities.
(f) Completed.
(g) An effective closed-conduit type expanding section was created in the structure by divider walls and a top cover so that smooth eddyless flow occurred without regions where fish could be entrapped.
- (4416) BLUE MESA DAM SPILLWAY.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:32.78 scale model is being constructed to study the radial gate controlled intake, the inclined tunnel, the vertical tunnel bend, the straight tunnel and the flip bucket for flows up to 33,650 cfs discharging at a velocity of 113 feet per second at the outlet portal.
- (4417) FONTENELLE DAM OUTLET WORKS.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:24.7 scale model was constructed to investigate the flow from three 11-foot-diameter circular conduits discharging through top-seal radial gates into three 14-foot-diameter horseshoe conduits leading to a common stilling basin. Eventually, a 10-foot-diameter power penstock will be installed in the right horseshoe conduit with a bifurcation and slide-gate controlled bypass located at the start of the stilling basin chute. Studies were made to develop the bypass structure so that the stilling basin derived for the original structure would be equally satisfactory for the modified structure.
(f) Completed.
(g) Satisfactory flow conditions were obtained in the original structure and the most favorable alignment for the bypass structure was determined. Pressure distribution and head loss measurements were also obtained in the bifurcation structure.
(h) Report in preparation.
- (4418) SANFORD DAM SPILLWAY AND FLOOD CONTROL OUTLET WORKS.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:46.42 scale model was constructed to study the hydraulic characteristics of the morning-glory spillway entrance, tunnel, chute, and stilling basin and the flood control outlet works entrance, chute and stilling basin and the influence which one feature has on the other during simultaneous operation. Tests are being conducted to determine a means of alleviating the vortex which occurs in the spillway entrance.
(g) The model study has shown that the features of the design other than the spillway entrance perform satisfactorily.
(h) Report to be prepared.
- (4419) WHISKEYTOWN DAM SPILLWAY.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:32.78 scale model was constructed to study the morning-glory intake, the vertical tunnel bend, the straight tunnel, the flip bucket, and the downstream river channel for flows up to 28,450 cfs discharging with a maximum velocity of 96 feet per second at the outlet portal.
(f) Completed.
(g) The following were developed during the study: Guide vanes for the crest, a deflector and air vent for the vertical bend, shape of the flip bucket, discharge channel alignment, and head discharge relationships for the spillway.
- (4420) FONTENELLE DAM SPILLWAY.
(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:30 scale model was constructed to investigate the design of a double side-channel spillway discharging into a sloping chute and hydraulic jump stilling basin.
(f) Completed.
(g) Minor modifications were made to the sloping chute between the spillway and stilling basin; otherwise, the design was found to be satisfactory.
(h) Report in preparation.
- (4421) SEDIMENT CONTROL AT DIVERSIONS.
(b) Laboratory project.
(d) Experimental; for design.
(e) Various devices are being studied to develop ways of reducing the amount of bed sediment entering canals.
(f) Tests partially completed.
- (4422) LABORATORY STUDY TO ESTABLISH THE STABILITY OF AN EARTH COVER MATERIAL OVER AN ASPHALT MEMBRANE LINED CANAL.
(b) Laboratory project.
(d) Experimental; for design.
(e) One side slope (2:1) and part of the canal bottom were reproduced in a test box. The test section was subjected to various rates of water surface drawdown up to 2 feet of drop per hour. The same test section was also exposed to 0.2- and 0.1-foot high waves.
(f) Tests completed.
(h) "Drawdown Tests on Earth Cover Material Placed Over an Asphalt Membrane--East Bench Canal--Missouri River Basin Project, Montana" by F. H. Geier and R. A. Dodge, Jr.
- (4423) RELATION OF SEDIMENT SUSPENSION AND SCOUR TO CHANNEL HYDRAULIC CHARACTERISTICS.
(b) Laboratory project.
(d) Experimental; for design.
(e) To determine the depth that a confined open channel will obtain when flows on an alluvial bed and when the size gradation of the sediment and hydraulic characteristics of the flowing water are known.
(f) Correlation analyses are being made of existing data. A tilting flume is being

designed to supplement existing data.

(4424) EQUILIBRIUM BEACH PROFILES.

- (b) Laboratory project.
- (d) Experimental; for design.
- (e) To determine equilibrium beach profile in terms of soil properties and in terms of waves expected at a reservoir site.
- (f) Model being constructed.

(4425) WATER-COLUMN SEPARATION.

- (b) Division of Design Project.
- (d) Theoretical and field investigation; applied research.
- (e) Field tests are being used to check theoretical developments designed to predict completely the hydraulic transient conditions occurring during separation and rejoining of water columns occurring during separation and rejoining of water columns in pump discharge lines.
- (g) Peak pressures higher than predicted were measured in the field.
- (h) Report to be prepared.

U. S. DEPARTMENT OF THE NAVY, DAVID TAYLOR MODEL BASIN.

Inquiries concerning the following projects should be addressed to the Commanding Officer and Director, David Taylor Model Basin, Washington 7, D.C.

(710) RESEARCH ON MAIN INJECTION SCOOPS AND OVERBOARD DISCHARGES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical; applied research.
- (e) Investigations to determine the characteristics of injection scoops and discharges to provide design data for use in design of future ships in both high and low speed ranges.
- (h) "A Survey of Condenser Scoop Literature," by C. L. Sayre, Jr., Report MEL-61 ONR Contract Nonr-3366(00)(X), June 1961. (Work done for TMB).

(711) CAVITATION RESEARCH.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical and experimental; applied research.
- (e) Research is being conducted on the mechanism and effects of cavitation phenomena in real and ideal fluids. (1) Linearized theory is being applied to determine cavity shapes and forces in steady flows. (2) Experimental studies of the growth of cavities on hydrofoils are to be made in both steady and unsteady flows (see project #3284).
- (g) A better correlation between theoretically and experimentally determined cavity shape has been achieved by modifying linearized cavitation theory to include surface tension effects.
- (h) "Surface Tension and Free Surface Effects in Steady Two-Dimensional Cavity Flow About Slender Bodies," by S. H. Schot, TMB Report 1566 (to be published about January 1962).

(1514) MANEUVERING CHARACTERISTICS OF SINGLE-SCREW VESSELS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental testing.
- (e) Measurements of side forces on propeller, rudder, and hull of a single-screw ship model during successive phases of starting, stopping, and backing maneuvers.
- (f) Inactive.
- (g) A test program has been formulated. A side-force dynamometer has been designed and completed. Testing is expected to begin when priority considerations permit.

(1521) 36-INCH VARIABLE PRESSURE WATER TUNNEL.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) New facility.
- (e) Design and construction of a 36-inch variable pressure water tunnel for investigation of propulsion, cavitation, and noise characteristics of propellers as well as tests on sub-surface bodies. Interchangeable test sections of open and closed jet type will be provided. The maximum design speed is 85 fps.
- (g) Estimated completion is end of 1961.

(1778) HYDRODYNAMIC NOISE.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic research.
- (e) Investigations of the characteristics of underwater noise associated with various hydrodynamic phenomena such as cavitation, bubble oscillation, turbulence and splashing. Particular attention is now being given to measurement of spectra and space-time correlations of pressure fluctuations on walls adjacent to turbulent flows, such as flat plate boundary layer flows and fully turbulent pipe flows.
- (g) Experimental and theoretical studies have been made of noise produced by cavitation, splashing, oscillating air bubbles, and turbulence.
- (h) "Resonant Frequencies of Pulsating Air Bubbles Generated in Short Open-Ended Pipes," by C. Devin, Jr., TMB Report 1522, July 1961.
- "Near Field Noise from Turbulent Jets," by D. W. Jorgensen, Journal of the Acoustical Society of America 33, 81/, 1961.

(1779) TURBULENT BOUNDARY LAYERS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical and experimental; applied research.
- (e) An experimental investigation of velocity profile and criteria for separation in a turbulent boundary layer with an adverse pressure gradient. Results will be compared with existing theories.
- (h) "The Behavior of Incompressible, Two-Dimensional Turbulent Boundary Layer with Adverse Pressure Gradient," by P. K. Chang and R. D. Cahn, TMB Report 1416 (in preparation).

(1781) ROTATING-ARM AND MANEUVERING BASIN.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) New facility.
- (e) Design and construction of a circular basin of 260-foot diameter with a rotating arm whose radius can be varied from 18 to 120 feet. To be used for towing tests of surface and sub-surface models. Also, design and construction of a maneuvering basin 350 feet long and 230 feet wide, equipped with traveling bridge and towing carriages, and wavemakers for the purpose of making maneuvering tests on ship models.
- (f) Completed.

(1783) MATHEMATICAL SHIP LINES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical research.
- (e) Development of a suitable method for the mathematical determination of ship lines which can be applied to a wide variety of ship forms especially to those of modern design.
- (g) A method has been developed for the mathematical fairing of graphical lines. This is a first step toward the development of a flexible system of mathematical ship lines. Future work is directed toward the development of a system of mathematical lines which will permit the derivation of a hull form for a given set of parameters.

- (h) "Mathematical Ship Surface," by Dr. P. C. Pien, TMB Report 1398, presents progress to date for this project.
- (1786) STUDIES OF THE SLAMMING OF SHIPS.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Experimental and theoretical basic research.
 - (e) Computations and measurements of the pressure distribution and impact forces on the bottoms of slamming ships for the purpose of developing design criteria to effect their reduction.
 - (g) The presently existing ellipse theory for estimating impact pressures is being generalized so that it may be applied to a wider range of bow sections with greater accuracy. The effect of bottom elasticity on impact pressures is being studied by dropping two dimensional elastic models onto a water surface.
 - (h) "Experiments on Rotational Impact," by M. D. Bledsoe and F. Schwartz, TMB Report 1145.
- (2019) SERIES 60 - PROPELLER EXCITED VIBRATION.
- (b) David Taylor Model Basin and Society of Naval Architects and Marine Engineers.
 - (d) Experimental basic research.
 - (e) Measurement of propeller induced vibratory forces on a series of models with variations in stern shape.
 - (g) The instrumentation and test techniques for measuring the propeller induced vibratory forces on a single screw ship model has been developed sufficiently to obtain repetitive results. Although there is insufficient information available to permit extrapolation to full scale forces, comparison of test results of models of similar type and dimensions appears valid. During the past year tests were conducted of a series of 3 models, based on the 0.70 C_B Series 60 parent form, with variations in stern section shape from U to V. Measurement of instantaneous pressure has been made on the hull of the USS TIMMERMAN and on the hull of a 30-foot model of that vessel. Preliminary data indicates that the model measurements when similarly extrapolated also produce higher values than were measured on board ship.
- (2229) NEAR SURFACE EFFECTS.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Hydrodynamic research.
 - (e) A mathematical study of the forces and moments acting on bodies due to the proximity of a free surface. The studies include both the case in which the surface is initially undisturbed and the case in which there are disturbances originating at a distance. Experiments are being conducted to verify the theoretical developments.
 - (g) Methods were developed for computing the forces and moments acting on bodies of revolution, both due to waves generated by the body itself and to regular trains of waves. Experiments with a spheroid moving under waves largely confirmed the theory except in following seas. The damping forces on a submerged translating ellipsoid which is oscillating in any of its six degrees of freedom have been developed theoretically. The effect of tank walls has been evaluated theoretically as well.
 - (h) "The Damping of an Oscillating Ellipsoid Near a Free Surface," by J. N. Newman, Journal of Ship Research, December 1961.
- (2230) THEORY OF SEAWORTHINESS.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Hydrodynamic research.
 - (e) A theoretical and experimental study of factors affecting the seaworthiness of ships,
- for the purpose of developing procedures for predicting their motion. The work is oriented in four directions: (1) Finding the equations of motion of a ship in a seaway, with the forces obtained from solutions of the boundary value potential problem. This approach will provide equations which are valid for transient as well as steady-state oscillatory conditions. (2) Validation of the more common technique of assuming that the longitudinal plane motions can be described by a system of linear second order differential equations with constant frequency dependent coefficients. The coefficients in the equations of motion are determined experimentally, as well as the forces on restrained models in regular waves. The motions of a free model can then be computed and compared with experiments to determine the validity of the theory. (3) Analytical and experimental studies of the damping of ship motions by free surface effects. (4) Determination of the form of a set of equations for the motions of a ship which are more reasonable physically than the second order constant-coefficient equations. Such equations will be derived in a heuristic manner, and certain parameters will be determined experimentally. The resulting equations should be valid for transient and steady-state sinusoidal motions. A restrained ship model has been towed in regular waves and the force and moment induced by the waves has been measured. Comparison of these data with calculations based on the Froude-Krylov hypothesis shows only qualitative agreement. Calculation of damping coefficients has been completed for Series 60 model, yielding generally excellent agreement with forced oscillation experiments. A mathematically defined model has been oscillated in pitch and in heave over a range of frequencies and forward speeds, to determine the coefficients for the assumed second order equations of motion.
- (2231) HYDRODYNAMIC ROUGHNESS STUDIES.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Theoretical and experimental; basic and applied research.
 - (e) Research on methods for analyzing and predicting the frictional resistance of arbitrarily rough surfaces such as the painted surfaces of ship hulls. The geometrical characteristics are to be correlated with the hydrodynamic characteristics.
 - (g) A new roughness profilometer has been built for use in curved surfaces and which is integrated into a magnetic tape recording system. A theoretical method has been devised for predicting the full scale resistance of arbitrarily rough surfaces from tests in model plates with the actual roughness. A high speed towing rig is under design and construction for these tests.
- (2232) PRESSURE AND VELOCITY DISTRIBUTIONS ON TWO-DIMENSIONAL AND AXISYMMETRIC THREE-DIMENSIONAL FORMS.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Theoretical; applied research.
 - (e) Investigate analytic techniques for determining the pressure and velocity distribution on two-dimensional and axisymmetric three-dimensional forms. The solution is to be amenable to coding for a high speed computer.
 - (f) Completed.
 - (g) This project has been terminated with the delivery of an IBM 704 program for computing pressure and velocity distribution on two-dimensional and axisymmetrical three-dimensional forms developed at Douglas Aircraft Co. under a TMB external research contract.
- (2235) LIBERTY SHIP SEAWORTHINESS.

- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Experimental.
 - (e) Thorough seaworthiness investigations of a Liberty Ship and a modified Liberty Ship hull. Full scale trials were conducted during several crossings of the North Atlantic. Speed reduction, ship motion stresses and slamming pressures were investigated.
 - (g) The motion and stress data obtained for special maneuvers conducted on each of the ships in approximately a State 5 sea have been analyzed and a comparative evaluation made for this particular oceanographic condition. Data obtained in all sea conditions have been analyzed and a final report comparing the two ships is in preparation. A data report presenting all spectra is being assembled.
- (2237) LIFTING SURFACE THEORY OF PROPELLERS.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Theoretical; applied research.
 - (e) Studies of the corrections on lifting line theory which arise from the finite extent of the blades.
 - (g) The available results are being applied to propeller design methods.
 - (h) "The Calculation of Marine Propellers Based on Lifting Surface Theory," by P. C. Pien, Journal of Ship Research, Vol. 5, No. 2, September 1961.
- (2462) PITCH REDUCTION STUDIES.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Experimental and theoretical.
 - (e) To determine the mechanism of occurrence and basic properties of horizontal hull vibrations induced by anti-pitching fins.
 - (g) To clarify the mechanism whereby the transverse vibrations are induced, a fiberglass model of the Mariner was tested and the fin loading, model motions and hull vibrations recorded. The effect of position of the fin along the hull on the vibration was studied. It was found that the vibrations are the result of an impact on the fin and/or bow due to collapse of a cavity and/or slamming. A 22 foot model was also tested on which the pressure distribution on the bow was measured along with the other variables mentioned above.
 - (h) "Hydroelastic Study of a Ship Equipped with an Anti-Pitching Fin," by K. M. Ochi, presented at the 1961 Annual Meeting of the Society of Naval Architects and Marine Engineers.
- (2463) STUDIES OF LOW ASPECT-RATIO CONTROL SURFACES.
- (b) David Taylor Model Basin; laboratory project.
 - (d) Experimental investigation; basic research.
 - (e) Determine the aerodynamic characteristics of a family of low aspect-ratio control surfaces which can be used by the designer of submarines and surface ships. Phase I is an investigation of a family of all movable control surfaces. Phase II is an investigation of the same family with plain flaps of different chord length.
 - (f) Phase I, Completed; Phase II, Completed.
 - (g) The results of Phase I indicate that many of the aerodynamic characteristics of low aspect ratio surfaces can be accurately predicted from lifting surface theory. The aerodynamic characteristics for an NACA 0015, aspect-ratio 2, movable control surface with 30, 40 and 50 percent flaps were obtained at the University of Maryland Wind Tunnel. The tests were conducted for the David Taylor Model Basin under U. S. Navy contract. Forces and moments for the complete control surfaces were obtained in the first part of the test. Forces and moments for the flap portion of the control surfaces were obtained in the second part of the test.
- (h) The results of Phase I and comparisons with lifting surface theory are presented in TMB Report 933. The results of the Phase II tests are presented in University of Maryland Wind Tunnel Report No. 268, December 1959.
- (2470) CAVITY RESONANCE.
- (b) Bureau of Ships; David Taylor Model Basin.
 - (d) Experimental and theoretical investigation of the excitations of cavity resonance by fluid flow.
 - (e) Studies to determine the mechanism of excitation of the cavity resonance by fluid flow past orifice will be undertaken. The experimental investigation will employ the low turbulence wind tunnel and circulating water channel. The amplitude of pressure fluctuations in the cavity will be investigated as function of the size, shape and number of orifices, as well as the turbulence characteristics in the boundary layer flow.
- (2471) THEORY OF CONTRAROTATING PROPELLERS.
- (b) Cooperative with the Bureau of Ships.
 - (d) Experimental and theoretical; applied research.
 - (e) Studies of the theory of contrarotating propellers without assumptions regarding the orientation of the resultant induced velocity. Open water and water tunnel tests to determine, experimentally, the effect of various propeller parameters.
 - (g) Application to open water and wake adapted propellers. Latest experiments have shown the performance to be insensitive to spacing between propellers so long as they are operated at their design spacing.
 - (h) "The Design of Contrarotating Propellers Using Lerbs' Theory," by W. B. Morgan, SNAME Trans., Vol. 68, 1960.
- (2472) COOPERATIVE TESTS ON A VICTORY SHIP DESIGN.
- (b) David Taylor Model Basin; Skin Friction Committee of the International Towing Tank Conference.
 - (d) Experimental testing; basic research.
 - (e) The investigation was authorized by the International Committee on "Scale Effect on Propellers," and on "Self-Propulsion Factors," as part of the international cooperative test program in ship basins. The International Committee will compare the results from the various basins and present a report to the coming International Conference. The tests will be carried out with a wax model of scale 1:23 equipped with different kinds of stimulators. The friction corrections will be calculated by the various basins according to their methods.
 - (g) The specified program of model testing has been completed. The required calculation for the power predictions have to be done before the evaluation work can proceed.
 - (h) Results have been reported to the International Towing Conference. A TMB Report is being prepared comparing TMB results with those of other basins.
- (2729) HULL FORM RESEARCH WITH A FLEXIBLE MODEL.
- (b) David Taylor Model Basin.
 - (d) Development and experimental work.
 - (e) A flexible model which can be quickly changed to have any fullness and any shape of section area curve is to be developed first. The effect of section area curve parameters, such as t_p , t_a , C_{pf} , C_{pa} , L_p , L_x , X_p , X_a , etc., upon resistance will be systematically investigated by using this flexible model.
 - (f) Inactive.
 - (g) The flexible model has been built and ex-

perimental test work begun. Thirty resistance tests have been conducted during the past fiscal year. Preliminary work with this flexible model indicates its adaptability for this work is satisfactory. An analysis of the test results has not been completed.

(2730) MOLECULAR - PHYSICAL SKIN EFFECT.

- (b) David Taylor Model Basin.
- (d) Experimental; applied research.
- (e) The frictional resistance of a "new" plate consisting of a special molecular coating will be compared with the frictional resistance of a hydraulically smooth brass plate and of a mirror smooth glass plate. The test equipment will be designed and constructed to study wave and spray formation for the determination of the true wetted surface. The plate will be tested with maximum speed of 15.0 knots and with various stimulation devices.
- (g) The Nikuradsi coated plates have been tested. Significant resistance differences between coated and non-coated plates have been measured on a coated brass plate and an uncoated aluminum plate. Since the contours of the leading and trailing edges of the two plates vary considerably doubt is raised as to whether the coating or the difference in the contours caused the resistance differences. A stainless steel plate having the same contours and the coated brass plate has been constructed and tested.

(2807) CONTROL SURFACE FLUTTER.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical; basin investigation.
- (e) Experiments are being conducted with a flutter apparatus to determine flutter speeds as a function of inertias, spring and damping constants. The results will be compared with a simplified rudder flutter analysis which can then be applied to design procedures.
- (f) Completed. Further work reported under Project No. 3285.
- (g) Flutter (a self-excited, oscillatory instability) of a small-aspect-ratio foil was produced in water, without free surface effects, at a speed of 20 ft/sec.

(2809) FLOW STUDIES ON THREE-DIMENSIONAL FORMS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical; basin research.
- (e) Pressure distributions and flow studies have been made in a wind tunnel on several shapes similar to those of certain sonar domes. Data will be used in predicting those conditions of ship speed, yaw and pitch which are conducive to cavitation on sonar domes.
- (f) Completed with publication of report.
- (h) "Pressure Distribution on Four Sonar Dome Bottoms," by R. D. Cahn, TMB Report 1491 (to be published about January 1962).

(2810) STUDIES OF HYDRODYNAMIC LOADING ON BARE AND FAIRED CABLES.

- (b) David Taylor Model Basin.
- (d) Experimental investigation; basic research.
- (e) Measure the tangential and normal hydrodynamic forces acting on a long cylinder towed at various angles to the stream over a range of Reynolds numbers. Tests will be made with various degrees of roughness simulating stranded cable, and various trailing-type fairing designs.
- (f) Discontinued.

(2871) FULL SCALE TRIALS AND MODEL PREDICTION CORRELATION.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental testing and re-evaluation of

existing test data.

- (e) The accuracy of full scale power predictions from model test results depends upon the selection of the proper correlation allowance (C_p) to be used in model calculations. Model tests have been conducted and past correlations have been re-analyzed such that a total of 54 correlations have been completed. An analysis of this data has begun.
- (g) Analysis of the completed correlations has begun and is scheduled for completion by 1 February 1962.
- (h) "Ship Standardization Trial Performance and Correlation with Model Predictions," by J.B. Hadler, C. J. Wilson and A. L. Beal, paper presented to the Chesapeake Section of the Society of Naval Architects and Marine Engineers on 7 December 1961. A classified report supplementing the data in this paper will be prepared.

(3284) UNSTEADY HYDROFOILS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical applied research.
- (e) The purpose of this work is to provide hydrofoil design criteria to the Bureau of Ships to be used in designing high speed, seagoing hydrofoil craft. The objective is to determine the steady and unsteady forces on hydrofoils due to heaving and pitching oscillations of the foil and due to encounters with regular head and following waves on the foil when operated in proximity to the free water surface. Both fully wetted and cavitating foil conditions are being studied. This work is related to Hydroelasticity (Reference No. 3285) and Cavitation (Reference No. 711) studies.
- (g) The unsteady lift force on a flat restrained hydrofoil advancing through regular head and following waves has been measured experimentally. The experimental data has been compared with theoretical data.
- (h) "The Unsteady Lift Force on a Restrained Hydrofoil in Regular Waves," by J. M. Steele, Jr., and D. A. Jewell, TMB Report 1408 (in preparation).

(3285) HYDROELASTICITY PROBLEMS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical applied research.
- (e) Investigations to determine the conditions which produce hydroelastic instability of oscillatory hydrofoil systems. The effects of speed, frequencies, mass distribution, cavitation, free surface and waves on the system stability will be studied. This work is related to Unsteady Hydrofoils (Reference No. 3284 and Cavitation Studies, Reference No. 711).
- (g) Flutter of a small aspect-ratio, fully-wetted foil was produced in water for a range of conditions in an earlier study and reported below. A two-dimensional analysis was used to predict critical speeds and frequencies in close agreement with the experimental data. The two-dimensional analysis was modified by use of engineering corrections for a three-dimensional configuration. The modified theory predicted critical conditions in slightly better agreement than the two-dimensional theory.
- (h) "Hydroelastic Instability of a Control Surface," by D. A. Jewell and M. E. McCormick, TMB Report 1442 (in preparation).
- "A Simplified Analysis of the Hydroelastic Instability of a Three-Dimensional Hydrofoil," by M. E. McCormick, TMB Report 1555 (in preparation).

(3286) THEORY OF SUPERCAVITATING PROPELLERS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical and experimental; applied research.
- (e) Studies and design of propellers designed

- to operate at high speeds.
- (g) The prediction and experimental confirmation of the performance of such propellers have been completed. Experimental performance of SC propellers, backing and at very low speed coefficients has been obtained.
- (h) "Experimental Performance of TMB Supercavitating Propellers 3767, 3768, 3769, 3770, 3785 and 3820," by R. Hecker and J.G. Peck, TMB Report 1553.
- "Applicability of a Supercavitating Propeller to a Small Speed Boat," by E. Venning, Jr., LCDR USN, TMB Report 1459.
- (3287) EFFECT OF STERN MODIFICATION TO A SERIES 60 VESSEL, RESISTANCE, POWERING, WAKE DISTRIBUTION AND PROPELLER INDUCED VIBRATION.
- (b) David Taylor Model Basin; Maritime Administration.
- (d) Experimental testing and evaluation of data for basic research.
- (e) Models representing specific variations in stern shapes and designed for special instrumentation installation will be built. The basic design will be the Series 60, 0.70 Block Coefficient Parent. Six other forms will be derived having systematic changes in section shapes (from V to extreme U) and for variation in waterline endings (from fine to blunt). An attempt will be made to develop formulation to mathematically express the stern variations from the parent.
- (g) The basic model has been constructed and powering data has been obtained.
- (h) "Effect of Hull Modifications on Resistance and Propulsion Characteristics of a Series 60 Stern, $C_D = 0.70$," by W. B. Hinterthan and E. E. West, TMB Report 1345.
- (3288) SHIP STABILIZATION.
- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical; applied research.
- (e) The roll response of an AK cargo vessel converted for use as a missile tracking station has been simulated on an analog computer to evaluate the stabilization accomplished by passive anti-rolling tanks. A description of the simulation, the ship response to regular wave action and some comparison with experimental values is presented in the report of the study.
- (f) Completed.
- (3292) EXPLORATORY STUDIES AND PLANS AT DTMB FOR MODEL TESTS IN 3-DIMENSIONS.
- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental; basic research.
- (e) A new seakeeping test facility is now in operation. Techniques for generating irregular short-crested seas and measuring the response of ship models at oblique headings is under development.
- (g) Segmented wave generators provide the ability to produce oblique waves. Programming to individual wavemakers results in generation of confused seas of almost any nature. The rectangular basin offers opportunity to test in any relative heading to the waves and even in cross seas. Problems in analysis involve determination of the seaway (in the tank) as a function of frequency and direction. Ship motions in confused seas will be random in nature and will be analyzed by spectrum methods.
- (h) "SPLASHNIK The David Taylor Model Basin Disposable Wave Buoy," by W. Marks and R. G. Tuckerman, TMB Report 1423.
- (3617) VENTILATED PROPELLER DEVELOPMENT.
- (b) David Taylor Model Basin.
- (d) Theoretical and experimental; applied research.
- (e) Studies and design of ventilated propellers for operation at intermediate speeds.
- (g) Experiments have been completed on the first ventilated propeller. Experiments are being performed on a second ventilated propeller design.
- (h) "Powering Performance of a Ventilating Propeller," by R. Hecker, TMB Report 1487.
- (3619) VERTICAL AXIS PROPELLER.
- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical; applied research.
- (e) Theoretical and experimental studies of performance characteristics of various types of vertical axis propellers.
- (g) Experimental work has been completed for cycloidal blade motion over a range of pitch ratios with 2, 3, and 6 blades and with blades of various types, for ahead thrust. Future work will deal with measurement of steering forces, determination of cavitation performance and performance with pitch ratios greater than π .
- (h) "Performance of Vertical Axis (Cycloidal) Propellers Calculated by Taniguchi's Method," by W. Haberman and E. E. Harley, TMB Report 1564, November 1961.
- (3620) PROPELLER PERFORMANCE IN UNSTEADY FLOW.
- (b) David Taylor Model Basin.
- (d) Experimental and theoretical; applied research.
- (e) Experimentation to evaluate the effect of various dimensional characteristics on the time dependent propeller forces while operating in waves. Correlation of results with wave theory.
- (f) Completed.
- (g) A 16" diameter bronze propeller has been tested in various waves. The thrust and torque coefficients were calculated for the wave crests and wave troughs. The wave velocity from the trochoidal wave theory was applied to the advance coefficients.
- (h) "The Performance of a Fully Submerged Propeller in Regular Waves," by W. H. Norley, J. H. McCarthy and G. L. Ober, TMB Report 1440, 1961.
- (3621) STUDY OF BENDING MOMENTS OF A SHIP MODEL MOVING IN WAVES.
- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical and experimental; basic research.
- (e) To provide ship designers with more exact information concerning the magnitude of bending moment and shear forces in a ship moving in waves.
- (g) Bending moment about the transverse axis and vertical shear forces were measured experimentally in regular head seas and results compared with analytical calculations of motions bending moments and shear forces. The above work was supplemented by additional tests in regular following waves.
- (h) "Experimental Determination of Bending Moments and Shear Forces in a Multi-Segmented Ship Model Moving in Waves," by Z. George Wachnik and Frank M. Schwartz.
- (3622) FLUCTUATING FLOWS.
- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical; basic research.
- (e) Investigations are being made of the fluctuating hydrodynamic forces on a body in a moving stream. The nature of the vortex shedding will be studied by obtaining a frequency spectrum of the transverse forces.
- (h) "Vortex-Induced Vibration Studies," by Morris S. Macovsky, July 1958.
- (3999) SHIP WAKE CHARACTERISTICS.
- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental; applied research.
- (e) Development of instrumentation for measuring turbulent velocities and thermal

microstructure in ship wakes. Measurements will be made to determine the rate of decay and dispersion of wakes.

(f)

Inactive.

(4000) DRAG REDUCTION BY BOUNDARY LAYER CONTROL.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Theoretical and experimental; basic and applied research.
- (e) Investigations into feasibility of achieving drag reduction by boundary layer control in applications to naval hydrodynamics. Tests are to be made on flat plates with flexible coatings which delay transition to turbulent flow. Other methods are also being studied.
- (g) Towing rig under design and construction.
- (h) "The Effect of Fluid Injection on the Drag of Flat Plates at High Reynolds Numbers," by P. S. Granville, TMB Report 1520, September 1961.
- "The Boundary Layer and Directional Resistance of Flat Plates in Non-Newtonian Fluids," by P.S. Granville (submitted for publication).

(4426) DEVELOPMENT OF A LOW WAVE DRAG HULL FORM - SERIES 64.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Basic research.
- (e) To establish a series of basic hull forms which can be used as a guide to evaluate the merit of future high speed ship designs. The basic test work has been completed. Thirty-three models were tested for resistance including 4 defining the parent form and 2 catamarans. The basic series covers the following range of coefficients C_B from 0.35 to 0.55 at constant C_D of 0.63, B/H from 2 to 4, $\Delta/(L/100)^3$ from 15 to 55. Analysis of data has begun.

(4427) A METHOD OF CALCULATING SPINDLE TORQUE OF CONTROLLABLE PITCH PROPELLERS.

- (b) David Taylor Model Basin.
- (d) Theoretical; applied research.
- (e) A method of calculating the spindle torque of a controllable pitch propeller over the complete range of operating conditions and a theoretical investigation of the effect of various design parameters upon spindle torque. In order to calculate spindle torque at off design conditions, the off design performance of the controllable pitch propeller must first be determined.
- (g) A method of calculating the spindle torque at design conditions has been completed. The geometric problem of determining the effective distortion of blade sections at off design pitch settings has been solved.
- (h) "A Method of Calculating the Spindle Torque of a Controllable Pitch Propeller at Design Conditions," by R. J. Boswell, TMB Report 1529, August 1961.

(4428) COMPUTER SOLUTIONS OF FREE SURFACE FORCES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic research.
- (e) The potential problem of a translating body oscillating on the free surface will be solved directly on a digital computer by distributing pulsating sources over the surface of the body and calculating the required source density. The individual source potentials are chosen to satisfy the free surface boundary condition.
- (g) The integral equations for source density have been formulated for the case of two-dimensional bodies with no forward speed. The numerical analysis and programming have been largely completed for this case.

(4429) LATERAL FORCES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic research.
- (e) The lateral force on a translating body which

vertically cuts the free surface is being formulated theoretically. Two special cases are included: (a) If the draft is large compared to the length, the body is a strut with angle of attack. (b) If the draft is very small, the body corresponds to a yawed thin ship.

- (g) An integral equation has been derived for the density of a surface distribution of dipoles, such that the boundary conditions are satisfied.

For sponsored projects see the following:

- (3026) Ship Resistance in Uniform Waves as a Function of Block Coefficient and Wave Steepness. 11
- (3685) Non-Linear Coupled Ship Motions. 11
- (3035) The Consequences of Model Restraint On Results of Seaworthiness Tests. 15
- (4099) Wake Characteristics for Bodies of Revolution. 18
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- (81) Mathematical Analysis of Pressure Distribution. 32
- (2802) Experimental Study of Wake Mechanics. 40
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U. S. DEPARTMENT OF THE NAVY, NAVAL BOILER AND
TURBINE LABORATORY.

(3623) HIGH PRESSURE-TEMPERATURE WATER FLOW METER
CALIBRATION.

- (b) Bureau of Ships; Philadelphia Naval Shipyard (Naval Boiler and Turbine Laboratory).
- (c) Mr. J. W. Murdock, Associate Technical Director for Applied Physics, Naval Boiler and Turbine Laboratory, Philadelphia Naval Shipyard, Phila. 12, Pa.
- (d) Experimental; applied research.
- (e) A facility is available for calibrating with water at pressures and temperatures up to 2500 psi and 600 F respectively. Capacity is 100 gpm at maximum pressure and temperature and greater at lower pressures and temperatures. After flowing through the metering section the water is cooled and weighed. The facility is also used to investigate and verify orifice meter coefficients at pressures and temperatures above those at which the coefficients in use were established.
- (g) A limited amount of test data indicate good agreement between orifice flow rates obtained by calibration at high pressures and temperatures and those obtained by extrapolating from cold water calibrations. Other meter tests show the need to include suitable corrections for change in shape, size, density, etc.

(3624) INVESTIGATION OF ELBOW FLOW METERS.

- (b) Bureau of Ships; Philadelphia Naval Shipyard; (Naval Boiler and Turbine Laboratory).
- (c) Mr. J. W. Murdock, Associate Technical Director for Applied Physics, Naval Boiler and Turbine Laboratory, Philadelphia Naval Shipyard, Phila. 12, Pa.
- (d) Experimental; applied research.
- (e) The 90-degree elbow has been proposed for metering flow in shipboard systems. This type meter is attractive since the use of an existing elbow would not require any changes to the piping and would impose no additional pressure drop on the system. The chief drawbacks are large variation in elbows and the lack of an exact relationship between flow and differential pressure. Testing will be limited to the long turn 90-degree, type A elbows of Specification MIL-F-1183 to establish criteria for their installation and use.

(4001) HIGH PRESSURE STEAM AND WATER FLOW TESTS.

- (b) American Society of Mechanical Engineers.
- (c) Research Committee on Fluid Meters, American Society of Mechanical Engineers, 345 East Forty-Seventh Street, New York 17, New York.
- (d) Experimental; applied research.
- (e) Although the ASME Research Committee on Fluid Meters has sponsored many fundamental research programs dealing with the development of basic constants used with primary elements, hardly any of this work has been done on steam flow at high pressures and temperatures. Neither has research been done on high temperature water flow. Analysis of many tests indicate that the basic calibrations obtained with low temperature water (air and gas) could be extrapolated with high accuracy to the measurement of high pressure and temperature steam and water flow provided suitable corrections were made for the change in the shape and size of the primary element, the pipe and the fluid. This procedure has been experimentally verified for steam up to 2000 psi and 1050° F and for water to 2500 psi and 600° F.

U. S. NAVAL ORDNANCE TEST STATION.

(3295) FORCED VENTILATION OF HYDROFOILS.

- (b) Bureau of Naval Weapons, Department of the Navy.
- (c) Commander, U. S. Naval Ordnance Test Station, Attn: T. G. Lang or A. G. Fabula, Code P5015, 3202 E. Foothill Blvd., Pasadena, California.
- (d) Experimental and theoretical; basic research.
- (e) The hydrodynamic lift, drag, pitching moment and pressure distribution are studied on hydrofoils of various cross-sections from which gas is exhausted through ports of varying shape and location. The results are applicable to torpedoes as a simple means of varying control forces on stabilizing fins and a new type of propeller blade cross-section.
- (g) Water tunnel tests show that the gas does not ventilate forward of the exhaust port unless the boundary layer has separated. A minimum value of air flow rate coefficient is required to properly ventilate the hydrofoils. The theoretical analysis and experimental results are essentially in agreement. Results indicate that base vented hydrofoils may operate at speeds as much as 50% greater than conventional streamlined hydrofoils without cavitating.
- (h) "Application of Thin Airfoil Theory to Hydrofoils with Cut-Off, Ventilated Trailing Edge," by A. G. Fabula, NAVWEPS 7571, Sept. 1960.
"Water Tunnel Tests of a Base-Vented Hydrofoil Having a Cambered Parabolic Cross Section," by T. G. Lang and Dorothy A. Daybell, NAVWEPS 7584, Oct. 1960.
"Linearized Theory of Vented Hydrofoils," by A. G. Fabula, NAVWEPS 7637, Mar. 1961.

(4002) MISSILE BEHAVIOR DURING WATER EXIT.

- (b) Bureau of Naval Weapons, Navy Department.
- (c) Commander, U. S. Naval Ordnance Test Station, Attn: Dr. John G. Waugh, Code P8074, 3202 E. Foothill Blvd., Pasadena, California.
- (d) Experimental; basic research.
- (e) The purpose of this project is to study missile water-exit behavior and associated phenomena under different conditions to determine if problems may exist in missile water-exit technology and to establish scaling techniques for modeling missile water-exit behavior.
- (g) Studies have been made on the water-exit behavior of a momentum-propelled 2-inch-diameter hemisphere-head missile under different degrees of cavitation, ranging from fully wetted to fully cavitating, and for a range of trajectory water-exit angles. The results indicate that considerable perturbations in missile pitch and pitch velocity take place at water exit, and it is inferred that problems may exist in missile water-exit technology.
- (h) "Recent Hydrodynamics Research at the Naval Ordnance Test Station," by J. G. Waugh, H. R. Kelly and A. G. Fabula, Naval Research (The Fifth Navy Science Symposium), ONR-9, Vol. 2, pp. 473-508, April 1961. Office of Naval Research, Department of the Navy, Washington, D.C.
"Water-Exit Behavior of Missiles, Part 1, Preliminary Studies," by J. G. Waugh and G. W. Stubstad. (NAVWEPS Report 7735, NOTS TP 2693), 11 May 1961, U. S. Naval Ordnance Test Station, China Lake, Calif.
"Missile Water-Exit Hydrodynamics," by J.G. Waugh, H. R. Kelly and A. G. Fabula, Undersea Technology, Vol. 2, No. 4, pp. 24-26, Sept/oct. 1961.

(4003) UNDULATING HYDROFOIL PROPULSION.

- (b) Bureau of Naval Weapons, Department of the Navy.
- (c) Commander, U. S. Naval Ordnance Test Station, Attn: Howard R. Kelly, Code 40006, China Lake, California.
- (d) Experimental and theoretical; basic research.

- (e) To measure the propulsive force on a thin, two-dimensional hydrofoil, undulating in sinusoidal motion, and compare with theory. Additional experimental work is being done with full-scale three-dimensional models of salmon, and with oscillating rigid hydrofoils.
- (g) Good agreement has been found with theories by Wu and Siekmann, showing positive thrust at high frequency and negative thrust at low frequency. Fair agreement is found between experiment and theory for power input and propulsive efficiency. Some thrust data has been obtained with the salmon model but no comparison with theory has been attempted, since no available theory adequately fits the experiment. The propulsive force for the rigid hydrofoils agrees well with theoretical predictions.
- (h) "Propulsion With an Undulating Thin Hydrofoil," by Howard R. Kelly, Glenn Bowlus, and A. W. Rentz. NAVWEPS Report, in preparation.
- "Fish Propulsion Hydrodynamics," a paper presented at the Midwestern Conference on Fluid Mechanics, East Lansing, Michigan, 6 September 1961.

(4430) ROTATING CYLINDER CONTROL.

- (b) Laboratory project.
- (c) Commander, U. S. Naval Ordnance Test Station, Attn: John D. Brooks, Code P8040, 3202 E. Foothill Blvd., Pasadena, Calif.
- (d) Experimental; applied research.
- (e) The purpose of the study is to investigate the effect of a rotating cylinder placed in the leading or trailing edge of a hydrofoil. It is hoped that the cylinder, rotating at high speed, will induce a Magnus effect type normal force on the hydrofoil, which could be used for the control of underwater vehicles. A water tunnel model is being constructed.

(4431) INTERNAL WAVES OF TIDAL PERIOD.

- (b) Laboratory project.
- (c) Commander, U. S. Naval Ordnance Test Station, Attn: M. J. Summers, Code P8051, 3202 E. Foothill Blvd., Pasadena, California.
- (a) Experimental; basic research.
- (e) Multi-ship arrays off the southern California coast for three separate 24 hour periods took bathythermograph readings at 15 minute intervals to study internal waves of tidal period. Completed in its present phase.
- (g) Semi-diurnal periods were found at each ship location. Investigation of the arrival times of wave crests revealed an apparent shoreward movement of the internal wave coming in roughly parallel with the continental slope and the continental shelf. Velocities were about seven knots in deeper water and about one knot atop the shelf in shallow water. There appeared to be an internal surf, or turbulence close inshore.
- (h) Report in preparation.

(4432) PROPELLER BLADE DESIGN FROM LIFTING SURFACE THEORY.

- (b) Bureau of Naval Weapons, Navy Department.
- (c) Commander, U. S. Naval Ordnance Test Sta., Attn: Mr. David M. Nelson, Code P8074, 3202 East Foothill Blvd., Pasadena, Calif.
- (d) Theoretical; applied research.
- (e) A theoretical method for designing propeller blades using lifting surface theory is being developed and will be programmed for the IBM 7090 computer. The chordwise streamline in the true three-dimensional flow is computed considering the bound circulation of the blades, the trailing vorticity, and the thickness of the blades. The bound circulation is allowed to have both an arbitrary chordwise and spanwise distribution. The elements of bound circulation are considered as continuous

lines conforming to the shape of the blade so that not only are aspect ratio effects accounted for but also plan form effects. Thickness effects are determined from thin airfoil theory.

(4433) RELATIVE FLOW ANGLE AT LIFTING LINE FOR COUNTER ROTATING PROPELLERS.

- (b) Bureau of Naval Weapons, Navy Department.
- (c) Commander, U. S. Naval Ordnance Test Sta., Attn: Mr. David M. Nelson, Code P8074, 3202 East Foothill Blvd., Pasadena, Calif.
- (d) Theoretical; applied research.
- (e) A theoretical means for determining the relative flow angle at the lifting line for counter rotating propellers is being developed and programmed for the IBM 7090 computer. This method is intended to handle non-optimum wake adapted propellers. The induced velocities at the lifting line arising from the effect of the front or rear propeller on itself are determined by a slightly modified version of the method developed by Lerbs*. The axial velocities at one propeller induced by the other are determined by replacing the finite bladed propeller by an infinitely bladed propeller having the same radial distribution of thrust and operating in the same wake. The tangential velocities at the rear propeller induced by the front propeller are determined by Stokes theorem. The effect of the tapering afterbody on which the propellers are located is approximately accounted for by continuity considerations. *"Moderately Loaded Propellers with a Finite Number of Blades and Arbitrary Distribution of Circulation," by H. W. Lerbs, Trans, SNAME, Vol. 60, 1952, pp. 73-117.

(4434) DUCTED PROPELLER RESEARCH.

- (b) Bureau of Naval Weapons, Navy Department.
- (c) Commander, U. S. Naval Ordnance Test Sta., Attn: Mr. J. F. Reynolds, Code P8074, 3202 East Foothill Blvd., Pasadena, Calif.
- (d) Theoretical; applied research.
- (e) This project includes an analysis and evaluation of present research in ducted propeller design methods and a determination of the applicability of these methods to the design of a pumpjet torpedo configuration. Pumpjet design methods require a knowledge of the boundary layer for a specified bare body configuration as well as the velocity increments resulting from the component parts of the ducted propeller system. Earlier pumpjet designs were based on the potential and frictional wake fraction due to the bare body alone and neglected the induced velocity increments effected by the individual components of the system and their mutual interaction. This over-simplification generally resulted in a pumpjet blade system which operated at off design conditions. For this reason any prediction of the noise performance of the system was not considered too reliable.
- The purpose of this project has been to assess the merits and limitations of the current ducted propeller design methods and replace the component parts of the ducted propeller with a system of singularities which will adequately describe the induced flow field. This will give a better estimate of the inflow velocities and net forces on the system and thereby improve its cavitation performance characteristics.
- (g) Present ducted propeller theory assumes uniformity of flow and therefore applies only to propellers which are free running. It has been found that such a propeller can become wake-adapted using an extension of Lerbs' technique to include finite circulation at the blade hub and blade tip. The ducted propeller can then be designed to match the boundary layer by calculating the distribution of pitch angle across the helical vortex sheet shed by the propeller.

The average shroud loading is readily obtained by applying Weissinger's solution for the zeroth harmonic of the shroud loading in which the total radial wash on the duct is known. The boundary layer profile for the bare body is combined with the velocity increments effected by the hub, propeller and average shroud loading as a first iterative step in computing the induced velocities required for a ducted propeller design. A pumpjet torpedo design utilizing this method will be programmed for the IBM 7090.		(3429)	Jet with Transverse Pressure Gradient.	34
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(c)	Commander, U. S. Naval Ordnance Test Station, 3202 E. Foothill Blvd., Pasadena, California, Attn: Paul C. Roberts, Code P8076.	(4164)	Boiling and Two-Phase Flow.	45
(d)	Experimental field investigation; applied research.	(3120)	Office of Naval Research Atmosphere Interaction and Wave Project.	51
(e)	A field test program was conducted by U. S. Naval Ordnance Test Station, Pasadena, in which an 11-inch diameter ventilated supercavitating propeller, designed by the David Taylor Model Basin, was fitted to a high speed torpedo (59 knots) and operated on an under-water cableway facility at a maximum depth of 66 feet. Torpedo and propeller performance data were obtained with varying amounts of oxygen gas being vented through the propeller blade holes.	(2374)	The Mechanism of Two-Phase Flow of Annular Liquids in a Vertical Tube.	59
(f)	Completed.	(2144)	Experimental and Analytical Studies of Hydrofoils.	62
(g)	The run data showed that the propulsive efficiency averaged about 79%. As gas was passed through the blade-ventilation holes in increasing amounts, the advance ratio progressively decreased by 10%, but it could not be concluded that the efficiency was directly affected. The propeller performance data agreed with water-tunnel results reported by other laboratories.	(3153)	Flow About Bodies at Small Cavitation Numbers.	62
(h)	"Studies of a Ventilating Supercavitating Propeller on a Torpedo Test Vehicle Part 1, Performance Results," by Paul C. Roberts, NAVWEPS Report 7628 Part 1, NOTS TP 2633, 32 pages, 21 February 1961.	(3821)	Strut Interference Effect on Hydrofoil Systems.	63
		(3822)	Flow Over Vibrating Plates.	63
		(4200)	Investigation of the Forces and Interference Effect of Tandem Flat Hydrofoils.	64
		(4213)	Long-Period Waves Over California's Continental Borderland.	66
		(4214)	General Study of Low-Frequency Gravity Waves in the Sea.	66
		(2154)	Investigation of Ship Motions and High Speed Ship Forms.	68
		(3174)	Unsteady Lift and Moment on Fully Cavitating Hydrofoils at Zero Cavitation Number.	69
		(3514)	Theoretical and Experimental Investigation of Flutter of Fully-Wetted Hydrofoils.	70
		(3517)	Ships of Minimum Wave Resistance.	70
		(3833)	Experimental and Analytical Study of Flutter of Submerged Hydrofoils.	71
		(4221)	Unsteady Forces and Motions on a Hydrofoil Moving Under an Irregular Sea.	71
		(4226)	Investigation of Surface-Piercing Fully Ventilating Dihedral Hydrofoils.	72
		(4227)	Smooth Water Behavior of Surface - Piercing Hydrofoil Vessel.	72
		(4229)	The Boundary Layer Under Progressive and Standing Waves.	72
		(3520)	Forecasting of Ocean Waves Generated by Movable Variable Wind Systems in Deep and Shallow Water.	74
		(1478)	Wind Waves.	147
		(2436)	Flow Over Hydrophobic Materials.	147
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		(4435)	Ventilated Supercavitating Propeller.	174

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(3377)	Theoretical Studies in Hydrodynamics.	2		
(4073)	Studies in Ventilating Flows and Ventilation of Hydrofoils.	2		
(3378)	Cavitation in Cascades.	2		
(2753)	Hydraulic Breakwater.	8		
(3677)	Annular Nozzle Ground Effect Machine.	10		
(3687)	Pressure Distributions, Added-Mass, and Damping Coefficients for Cylinders Oscillating in a Free Surface.	11		
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(4084)	Ships of Minimum Resistance.	11		
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(4112)	The Discharge of Major Western Rivers in Relation to the General Circulation of the Atmosphere.	20		
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(81)	Mathematical Analysis of Pressure Distribution.	32		
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TENNESSEE VALLEY AUTHORITY, Engineering Laboratory.				
Inquiries concerning the following projects should be addressed to Mr. Rex A. Elder, Director, TVA Engineering Laboratory, P. O. Box 37, Norris, Tenn.				
(731)	SOUTH HOLSTON DAM, SURGE TANK MODEL STUDY.			
(d)	Experimental; for design.			
(e)	A 1:50 model of the penstock and surge chamber was used to determine (1) the orifice size and characteristic shape to produce favorable pressure and water surface elevations to be expected in the surge chamber; and (2) the operational characteristics of the selected design.			
(f)	Model studies completed.			
(g)	With the proper orifice between the riser and the surge chamber as satisfactory results			

- can be obtained as with the differential riser type of surge tank.
- (h) Report in preparation.
- (762) SOUTH HOLSTON DAM, SURGE TANK PROTOTYPE CHECK TESTS.
- (d) Field investigation; applied research.
- (e) The prototype installation was equipped to allow testing in a manner similar to that used in the model studies which established the design. A check on the model accuracy can thus be obtained.
- (g) Tests made in February 1951, July and Oct. 1958 at headwater elevations 1630, 1719, and 1690, respectively.
- (2479) WILSON LOCK HYDRAULIC MODEL STUDIES.
- (d) Experimental; for design.
- (e) The new Wilson lock is 110 feet wide, 675 feet center-to-center pintles with a 100-foot maximum lift. A 1:36 scale model of a single transverse lateral with 12 ports was used to determine the proper lateral and port designs. A 1:16 scale model of the lock chamber, intake, culverts, gates and other details was used to determine the overall designs.
- (f) Laboratory model studies completed.
- (g) The basic design for the filling and emptying systems was determined from the model studies. Filling will be achieved through the use of 6 lateral culverts each containing 12 equally spaced ports 3.5 ft. high by 1.5 ft. wide. The upper three laterals will be fed from the landward main culvert and the lower three laterals by the riverward culvert. At minimum tailwater elevation only 23 ft. of water cushion is available at the bottom of the controlling reverse-flow tainter valves. Dangerously low pressures were eliminated by use of a fast initial opening rate followed by a slow rate for the major portion of the opening and by modifications of the valve shape and of the upper seal nose design. A stepped lateral design was found necessary to produce stable flow conditions.
- (h) Report on lock filling and emptying system in preparation.
- (2973) REVISION TO PRESENT WILSON NAVIGATION LOCK.
- (d) Experimental; for design.
- (e) Upon completion of the new Wilson Lock construction, the tailwater in the navigation canal at the dam will be lowered 10 feet. To make the present two-lift lock operable under the new conditions, the lower chamber floor will be lowered 10 feet and a new filling and emptying system provided.
- (f) Model studies have been completed to determine the exact hydraulic design to be used in the renovations.
- (g) The new filling system consists of a single culvert located on the longitudinal centerline of the lock with ports located near the bottom along both sides. The old valves are much above tailwater elevations; therefore, the culverts above tailwater were reduced in cross-sectional area to minimize the air entrainment problems.
- (h) Report in preparation.
- (3299) WILSON POWERHOUSE EXTENSION, HYDRAULIC MODEL STUDIES.
- (d) Experimental for design.
- (e) A 1:28.5 scale model of two turbine intakes and one spillway bay was constructed to determine (1) if there is a possibility of air being drawn into the intakes; (2) if changes will be required in the shape of the intake mouths and trash rack arrangement to improve flow conditions; and (3) if the flow through the adjacent spillway bay will effect the flow into the intake.
- (f) Model studies completed.
- (g) Design requirements in renovating an existing structure made it necessary to locate the turbine intakes closer to the water surface than is normally desirable. The model tests indicated that vortices would form at the intakes and air might be drawn into the units. The vortex action was essentially eliminated by installing a specially designed vortex eliminating structure above the intakes to the units.
- (h) Internal reports issued.
- (3300) HIWASSEE, PUMP TURBINE RATING.
- (d) Field investigation; operation.
- (e) Measurements of the discharge and differential pressures in the pump turbine scroll case have been used to establish the discharge rating for the pump turbine over all operating conditions. The discharge was measured by using Apalachia reservoir as a volumetric tank. Water was both pumped from the reservoir and discharged into the reservoir for a period of 12 hours. The reservoir area was obtained from aerial photographs taken at the beginning and end of each test. Five recording gages were used to measure the reservoir level. From these measurements the volume and corresponding discharge was computed.
- (h) Report in preparation.
- (3302) WIDOWS CREEK STEAM PLANT, AIR AND GAS DUCT TESTS.
- (d) Experimental; for design.
- (e) Model studies were conducted to improve flow conditions and reduce pressure losses in the gas duct which will carry gases from the furnace to the smoke stack for a 500-mw unit. Calibration of the air foil metering section in the forced-draft fan inlet ducts was also made by model studies.
- (f) Model studies completed.
- (g) Flow conditions were improved by use of flow straighteners and vanes.
- (h) Internal reports issued.
- (3303) WIDOWS CREEK STEAM PLANT, CONDENSER WATER PUMP TESTS.
- (d) Field investigations; operation.
- (e) Condenser water pump acceptance tests on three pumps for a 500 MW steam turbine were conducted to determine the flow, head, and power requirements in accordance with the latest ASME test codes for centrifugal pump and hydraulic prime movers modified to use pitometer traverses. Velocity measurements were made in the 9-foot, 6-inch square concrete pump discharge conduit.
- (f) Field tests completed.
- (h) "Discharge Measurements by Pitot Traverses in 114-Inch Square Conduit," by R. A. Elder and M. N. Smith, a paper presented at the ASCE Convention, Phoenix, Arizona, April 1961.
- (3628) KINGSTON, GAS DUCT MODEL STUDIES.
- (d) Experimental; for design.
- (e) A comprehensive 1:16 scale model study of the gas duct system which carries gases to the stacks has been conducted to (1) reduce pressure losses in the duct system; (2) determine the effect of the flow distribution within the existing duct on the operation of the mechanical fly ash collector; and (3) determine a means of obtaining a uniform velocity distribution through the proposed electrostatic precipitators.
- (f) Model studies completed.
- (g) Flow conditions were improved and pressure losses reduced in the ducts by use of flow straighteners and vanes. The mechanical collector was found to be an efficient flow distributor and any non-uniformity in the flow approaching it would be removed. A uniform velocity distribution through the

- electrostatic precipitator was obtained by the use of perforated plates, suitable vaning and flow straighteners in the approach duct.
- (h) Internal reports issued.
- (3629) LCW POWER VHF RADIO GAGES FOR REPORTING RAINFALL AND STREAM LEVEL DATA.
- (d) Development.
- (e) Transistorized radio components operating from nickel cadmium batteries charged by solar cells will be used. Data in binary coded decimal form will be transmitted by audio tone pulses. Long-term, unattended operation is a primary consideration in design.
- (4005) MELTON HILL LOCK, HYDRAULIC MODEL STUDIES.
- (d) Experimental; for design.
- (e) The proposed lock will be 75 feet wide by 400 feet long with a maximum lift of 60 feet. A 1:16 scale model of the lock chamber, intakes, culverts, gates and other details has been constructed to determine the overall design.
- (f) Laboratory model studies completed.
- (g) The filling system design was patterned after the multi-port filling system that was initially used in the Wheeler lock model studies. A total of 434 eight-inch pipe ports were used to discharge the water into the lock chamber from the 8' x 13' side culverts in the lock walls. Final tests indicate a lock filling time of 9.5 minutes. Forces measured on 4 barges during filling and emptying tests did not exceed 2.4 tons. The overall results of the testing program indicate that the multiple port filling system will provide excellent lock operation at Melton Hill.
- (h) Internal report issued.
- (4006) COLBERT STEAM PLANT, GAS DUCT MODEL STUDIES.
- (d) Experimental; for design.
- (e) A 1:16 scale plexiglass model of the gas duct extending from the air preheater through the stack was constructed to (1) obtain a uniform velocity distribution at the entrance to the electrostatic precipitator; (2) develop a satisfactory duct system to carry the gas from the electrostatic precipitator to the stack, and (3) reduce headlosses in the duct system. Test results were evaluated by observing smoke traces and from measurements of velocities and pressures at critical locations in the duct system.
- (g) General improvements in the operation were accomplished by installing flat plate vanes at the bends in the duct to guide and direct the flow of gas through the duct system. Two perforated plates with 38% and 50% of the area open, installed upstream from the electrostatic precipitator, in conjunction with the flat plate guide vanes, made it possible to obtain a uniform velocity distribution at the entrance to and through the electrostatic precipitator. Headlosses in the duct system were reduced by the installation of the flat plate vanes. Vanes installed in the stack opposite the breeching aided in turning the flow up at stack and materially reduced the headlosses.
- (h) Internal report issued.
- (4007) AIR FOIL METER.
- (d) Basic research; for design and MS thesis.
- (e) A model study was conducted to develop an air foil metering section for measuring the air flow to the furnaces at large steam plants. Consideration was given to developing an accurate meter which will cause a minimum pressure loss in the system.
- (g) The optimum shape of the air foil meter was initially developed from 1:16 scale model tests of the Widows Creek Steam Plant air duct. The air foil as developed consists of a circular nose with a flat, V-shaped tail attached to the downstream side. Differential pressures were measured between the front face of the meter and at points 60 to 110 degrees to the left or right. Initial tests using air as the medium of flow developed data for Reynolds Numbers up to 4×10^4 . The data were further extended using water as the medium of flow. Reynolds Numbers up to 2×10^5 were obtained with this setup. Data thus far have been obtained for ducts whose ratios of width to height were 2:1 and 8:1 and for meters whose ratios of meter width to duct width vary between 0.156 and 0.467. The test results have indicated that the maximum pressure differential occurs when the pressure is measured between the front face of the meter and a point offset 80 to 85°. Head loss caused by the meter is exceptionally small.
- (h) "Characteristics of a Simplified Stationary Airfoil Flowmeter," by M. N. Smith, M. S. Thesis, 1961, Univ. of Tennessee Library, Knoxville, Tenn.
- (4008) TURBULENCE SCALING.
- (d) Basic research.
- (e) No sound theoretical or experimental data are available to indicate the method that should be used for scaling either turbulent induced pressure fluctuations, frequencies or amplitudes as immediately related to flows in lock culverts. As a result a series of tests are being conducted on circular pipes 4, 6 and 24 inches in diameter to establish the correlation factors.
- (g) The results of the first series of tests are now being analyzed. The results, although not complete or decisive, indicate the scaling probably follows Froude relationships.
- (h) "Model-Prototype Turbulence Scaling," by Rex A. Elder, paper presented at the Ninth Congress of the International Association for Hydraulic Research, Dubrovnik, Yugoslavia, 1961.
- (4010) WHEELER LOCK OUTLET STUDIES.
- (d) Experimental; for design.
- (e) A 1:30 scale model studies conducted to develop a lock culvert outlet design which would eliminate heavy wave action that could adversely affect navigation.
- (f) Model studies completed.
- (g) The final model design consisted of a 20-foot diameter vertical outlet pipe surrounded by a wave absorbing wall structure 103-feet in diameter.
- (h) Internal reports issued.
- (4437) MELTON HILL PROJECT, TURBINE INTAKE GATE STUDIES.
- (d) Experimental; for design.
- (e) Tests were conducted on a 1:12 scale model to develop a three-leaf intake gate design that would satisfactorily shut off the turbine flow for the runaway condition (a discharge of 17,000 cfs per unit) without exceeding the capacity of a 25-ton Gantry crane.
- (f) Model studies completed.
- (g) Basic shape tests indicated that a combination of positive and negative lip shapes would produce a workable design, i.e., the three gate leaves seat satisfactorily; have smooth motion throughout the lowering operation; no slack lifting cables occur; and the total maximum crane loads are within the allowable limits.
- (h) Internal reports issued.
- (4438) WHEELER AUXILIARY LOCK OUTLET.
- (d) Experimental; for design.
- (e) A double-culvert, bottom outlet discharge system located across the approach canal

immediately below the lower miter gates was tested. Twelve vertical flow deflectors were used to distribute the flow evenly across the canal.

(f) Model studies completed.

(g) The final design made use of a 9-minute emptying valve opening time. This produced an 11.7 minute emptying time and a discharge operation sufficiently quiet to allow barges to be moored within 30 feet of the outlets.

(h) Internal reports issued.

(4439) DENSITY UNDERFLOW WITHDRAWAL STRUCTURES.

(d) Experimental; applied research.

(e) A three-dimensional model was used to develop the basic relationship involved in the design of skimmer wall structures used to insure the withdrawal of the bottom layer in a two-layered, density stratified reservoir.

(f) Laboratory study completed.

(g) Design curves were developed which will permit design of structures which will insure withdrawal of only the bottom layer or of withdrawal of the bottom layer plus 1 percent, 2 percent or 5 percent of the flow from the top layer.

(h) Report in preparation.

(4440) INTERNAL DENSITY CURRENTS CREATED BY WITHDRAWAL FROM A STRATIFIED RESERVOIR.

(b) This was a cooperative study with the U.S. Corps of Engineers, U. S. Army District, Walla Walla, Engineering Division, Planning and Reports Branch, Walla Walla, Washington.

(d) Theoretical evaluation of field data.

(e) A study of several years of temperature soundings taken in TVA's Pontana Reservoir was made in an attempt to determine the thickness of the withdrawal layer when water is withdrawn from a deep, thermally stratified reservoir at an intermediate elevation.

(f) Study completed.

(g) A plausible curve was developed, based on a theoretical analysis and established from the field data.

(h) Report in preparation.

(4441) MEASUREMENT OF KAPLAN TURBINE DISCHARGES USING OTT COMPONENT CURRENT METERS.

(d) Equipment development and field measurement operation.

(e) A measuring technique is being developed with which the flows through Kaplan type turbines can be accurately measured by use of Ott component type current meters which can vertically traverse the flow at the turbine intake gate slots. These measurements, made at several fixed discharges, will be used to calibrate Winter-Kennedy scroll case pressure taps. The Winter-Kennedy taps will then be used, with suitable measuring equipment, to determine the discharge for any turbine loading.

(g) The carriage framework upon which the Ott component type current meters will be mounted, along with their associated lifting devices, and the necessary recording instrumentation has been designed, constructed and field tested. Development of the actual measuring techniques is now in progress.

(4442) NEW WHEELER LOCK CULVERT ENTRANCE MODEL.

(d) Experimental; for design.

(e) 1:25 scale model studies are being conducted to develop acceptable flow conditions in the area of the new Wheeler lock culvert entrances. A prior study has been outmoded by the failure of the Wheeler auxiliary lock and subsequent design revisions.

Inquiries concerning projects should be addressed to Mr. James Smallshaw, Chief, Hydraulic Data Branch, Tennessee Valley Authority, Knoxville, Tennessee.

(765) EVAPORATION IN THE TENNESSEE BASIN.

(d) Field investigation; applied research.

(e) To provide data for estimating reservoir losses and derive a general rule, applicable to the Basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.

(h) Results published in monthly and annual bulletins, "Precipitation in Tennessee River Basin" (Project 768).

A supplemental report to that bulletin entitled "Evaporation in Tennessee River Basin," published in January 1961, summarizes the results of 25 years of observations, 1935 through 1959.

(768) PRECIPITATION IN TENNESSEE RIVER BASIN.

(d) Field investigation; basic research.

(e) A comprehensive study of rainfall and other weather phenomena for purposes of water dispatching and improvements in water control; storm studies as related to maximum precipitation, rainfall-runoff, spillway design and operation, etc.

(h) Monthly and annual bulletins, "Precipitation in Tennessee River Basin."

(769) RESERVOIR AND STREAM TEMPERATURES.

(d) Field investigation; basic research.

(e) Study of water utilization and water movement as concerns industrial plant locations and stream pollution. Variations in temperature from surface to bottom in reservoirs throughout the year are determined by soundings, and by continuous recording gages in natural streams.

(771) GALLERY DRAINAGE IN LARGE DAMS.

(d) Field investigations; design.

(e) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

(779) MAXIMUM POSSIBLE PRECIPITATION IN TENNESSEE VALLEY.

(b) Cooperative with U. S. Weather Bureau.

(d) Theoretical; applied research.

(e) Hydrometeorological analysis of large storms with upward adjustments of controlling factors to maximum limits as applied to the Tennessee Valley and subdivisions.

(g) Results to be published as one of current series of hydrometeorological reports by the U.S.W.B. and cooperating agencies.

(780) PERIODIC EVALUATION OF GROUND-WATER STORAGE.

(d) Theoretical; operation.

(e) By analysis of current records of stream discharge, the volumes of runoff in ground-water and channel storage are determined for use in operation of multi-purpose reservoirs.

(g) Results reported monthly and weekly within the organization.

(785) SEDIMENTATION OF EXISTING RESERVOIRS.

(d) Field investigation; basic research.

(e) Selected ranges in reservoirs are probed and sounded, volumetric samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of down-stream reservoirs, and probable sedimentation in future reservoirs.

(h) "Reservoir Sedimentation Data for Reservoirs in the Tennessee Valley," bringing previously

submitted information up to date through 1960, was submitted in October 1961 to the Subcommittee on Sedimentation, Interagency Committee on Water Resources, for publication in their bulletin.

(3306) COOPERATIVE RESEARCH PROJECT IN WESTERN NORTH CAROLINA.

- (b) Project conducted in cooperation with North Carolina State College of Agriculture and Engineering.
- (d) To determine water-land relationships for some of the principal soils used for agricultural purposes in western North Carolina under important vegetative covers. Observations include rainfall, runoff, soil-moisture, potential evapotranspiration, and actual evapotranspiration.
- (e) A statistically designed rotation of four covers on four small watersheds and a separate evaluation of deep-rooted crop on a fifth watershed.
- (f) Field studies of the deep-rooted crop, alfalfa, have been discontinued.
- (g) Results to date are summarized in annual reports on the project.
- (h) "Evapotranspiration Research in Western North Carolina: A North Carolina - Tennessee Valley Authority Cooperative Effort," by C. B. England and E. H. Lesesne; presented to American Society of Agricultural Engineers, Memphis, Tennessee, December 1960. "Runoff from Small Mountain Watersheds in Relation to Various Crop Covers and Soil Characteristics," by C. B. England and E. H. Lesesne; pending publication in Journal of Soil and Water Conservation, January 1962.

(3307) PARKER BRANCH PILOT WATERSHED RESEARCH PROJECT.

- (b) Project conducted in cooperation with North Carolina State College of Agriculture and Engineering.
- (d) To determine the effects upon the hydrology of the watershed of an intensive farm development program designed to give the optimum economic well-being of the people using the land. Rainfall, runoff, suspended and deposited sediment are observed, periodic soils-land-use and inventories are made and records of income summaries and public and private investments are maintained.
- (e) Project activities are divided into calibration, action, and evaluation phases.
- (g) Results to date are summarized in annual report on the project.
- (h) "Economic and Hydrologic Developments in the Parker Branch Watershed," by E. L. Baum and A. J. Coutu, Journal of Soil and Water Conservation, Volume 14, No. 6, pp. 260-265, November 1959.

(3308) WHITE HOLLOW WATERSHED.

- (a) To study the effect of changes in the

vegetal cover on a watershed taken out of cultivation on the hydrologic factors of runoff and soil erosion.

- (e) Continuous record from 1935 of rainfall, runoff, and suspended sediment, and periodic determination of vegetal cover indexes.
- (g) During the 24-year period 1935-1958, the forest cover improvement in the watershed resulted in greater watershed protection with no measurable change in water yield, no change in volume of either surface runoff or ground-water runoff, marked reduction in summer peak rates of discharge with lesser reduction in winter rates, a prolongation of the period of draining of surface runoff from the channel system, and a 96 percent reduction in the sediment load.
- (h) "Forest Cover Improvement Influences upon Hydrologic Characteristics of White Hollow Watershed 1935-1958," Report No. O-5163A, TVA.

(3309) PINE TREE BRANCH WATERSHED.

- (d) To determine the effects upon the hydrology of the watershed by reforestation and erosion control measures.
- (e) Continuous record from 1941 of rainfall, runoff, ground water, and sediment loads.
- (g) During the 19-year period 1941-1959, the cover improvement and erosion control in the watershed resulted in a decrease in surface runoff volumes and an increase in ground-water discharges, marked reductions in summer and winter peak flood discharges, a reduction in overland surface velocities, a prolongation of the period of draining of surface runoff from the channel system, an appreciable decrease in water yield, and a 95 percent reduction in sediment load.
- (h) Report in preparation covering the erosion control and cover improvement influences upon hydrologic characteristics during the period 1941-1960.

(4011) NORTH FORK CITICO CREEK RESEARCH WATERSHED.

- (b) Project conducted in cooperation with U.S. Forest Service.
- (d) Field investigation; basic research.
- (e) To determine the effects of normal, high-standard National Forest Multiple-use management upon the hydrology of the area. Observations include rainfall, runoff, air and water temperature, and humidity. Timber inventories, soil surveys, wildlife inventories, and evaluations of soil disturbances will be made. Project activities are divided into calibration, development, and evaluation phases.
- (g) Results will be published in annual reports. Progress Report No. 1, June 1960 - Feb. 1961, was published in May, 1961 for distribution to cooperating agencies.
- (h) "Water, Timber, Wildlife Studied in Tellico Area," the Tennessee Conservationist, June 1961.

Inquiries concerning the following projects should be addressed to Mr. I. W. McCaig, Hydraulic Engineer, H. G. Acres and Company Limited, Consulting Engineers, Niagara Falls, Canada.

- (3630) FRICTION FACTOR TESTS IN LARGE PRESSURE CONDUITS; BERSIMIS NO. 1 AND CHUTE-des-PASSES HYDRO-ELECTRIC DEVELOPMENTS.
- (b) Quebec Hydro-Electric Commission, Aluminum Company of Canada Limited.
 - (d) Field investigation; design.
 - (e) For the extension of data on friction in concrete-lined tunnels, an inspection was made of the 31-foot diameter Bersimis No. 1 tunnel and the 35-foot diameter Chute-des-Passes tunnel. The tunnel surface was classified in six categories. Plaster casts of each type of surface permitted evaluation of construction methods. Friction losses were measured at various tunnel discharges.
 - (f) Results of friction loss measurements still to be analyzed.
 - (g) Depending on the care taken during construction, the surface roughness of concrete poured against steel forms varied between 0.002 and 0.02 inches. Roughness between 0.005 and 0.01 inches was measured on the screened invert finished by steel trowelling. Finishing invert with wood floats gave a roughness between 0.035 and 0.050 inches.

- (4443) SPILLWAY RATING CURVES FOR FLOW OBLIQUE TO SPILLWAY PIERS.
- (b) New Brunswick Electric Power Commission.
 - (d) Experimental; design.
 - (e) For the extension of data on spillway discharge coefficients for flow oblique to spillway piers.
 - (f) Tests completed.
 - (g) Significant reduction in spillway discharge coefficient for shallow depth and flow entering at angle of 45 degrees to bridge piers.

- (4444) SPILLWAY MODEL TESTS FOR MANICOUAGAN 2 HYDRO-ELECTRIC DEVELOPMENT.
- (b) Quebec Hydro-Electric Commission.
 - (d) Experimental; design.
 - (e) Tests were carried out on a topographic model, scale 1:110 to determine the limits of location for a bucket spillway. Discharge from the spillway could threaten a road and bridge downstream.
 - (f) Tests completed.
 - (h) Report submitted to sponsor.

- (4445) DIVERSION CHANNEL MODEL TESTS FOR MANICOUAGAN 2 HYDRO-ELECTRIC DEVELOPMENT.
- (b) Quebec Hydro-Electric Commission.
 - (d) Experimental; design.
 - (e) Tests were made on 1:110 scale model of the diversion channel with surrounding topography. The flow capacity of the channel and the height of standing waves in the supercritical flow were of special interest.
 - (f) Completed.
 - (g) The tests showed that a moderate amount of channel curvature was acceptable at its upstream end, but that the height of standing waves caused by channel curvature further downstream required construction of uneconomically high channel walls.
 - (h) Report submitted to sponsor.

- (4446) DIVERSION TUNNEL MODEL TESTS FOR MANICOUAGAN 2 HYDRO-ELECTRIC DEVELOPMENT.
- (b) Quebec Hydro-Electric Commission.
 - (d) Experimental; design.
 - (e) Tests were made on a 1:110 scale model of the diversion tunnel, which included its inlet and outlet. The object of the tests was to determine minimum economic inlet and outlet

loss coefficients and to examine the tunnel's capacity to transport logs.

(f) Tests in progress.

UNIVERSITY OF ALBERTA.

- (4015) SCOUR ROUND BRIDGE PIERS.
- (b) Alberta Government Research Council, Department of Highways and University of Alberta.
 - (c) Mr. C. R. Neill, Hydraulic Engineer, Research Council of Alberta, Edmonton.
 - (d) Experimental; applied research.
 - (e) Field measurement of scour round bridge piers in alluvial rivers using echo sounders. Laboratory model studies.
 - (g) Equipment improved and some field data obtained. Some foreign literature on model studies translated.
 - (h) See items 4014, 4015 in 1961 issue of Hydraulic Research in the United States.
- (4447) HYDRAULICS OF CORRUGATED-METAL CULVERTS.
- (b) Alberta Government Research Council, Department of Highways and University of Alberta.
 - (c) Mr. C. R. Neill, Hydraulic Engineer, Research Council of Alberta, Edmonton.
 - (d) Laboratory and field experiments; applied research; initial stages used for master's thesis.
 - (e) Field experiments on 60" C.M. culvert and laboratory experiments on 15" C.M. culvert and 3 1/2" model, to measure hydraulic capacity at different stages and slopes and to develop design charts for all sizes.
 - (f) Experiments completed; preparation of design charts continuing.
 - (g) Roughness coefficient obtained for structural plate corrugated-metal pipe. Comprehensive type of design chart developed; charts for several sizes now published.
 - (h) "Hydraulic Investigations Related to Large Corrugated-Metal Culverts," by C. R. Neill, master's thesis, 1961.
"The Hydraulic Capacity of Large Corrugated-Metal Culverts," by C. R. Neill, EIC Annual General Meeting, Paper No. 4, 1961.

UNIVERSITY OF BRITISH COLUMBIA, Hydraulics Lab.

Inquiries concerning the following projects should be addressed to Prof. E. S. Pretious, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, Canada, unless otherwise indicated.

- (1044) FRASER RIVER MODEL.
- (b) Hydraulic model studies cooperative with the Department of Public Works of Canada, Vancouver, B.C.
 - (d) Experimental project to aid Federal Government engineers improve navigation conditions on the Fraser River estuary. The Department of Public Works, Canada, is responsible for providing adequate depths for shipping and controlling the construction of any river structures which might affect navigation on the estuary.
 - (e) An outdoor erodible-bed tidal river model to study methods for improving and maintaining the depths in the navigation channels of the Fraser River estuary with a minimum of dredging. Horizontal scale 1:600, vertical scale 1:70. The model occupies approximately 3 acres of the campus and represents the tide-water reaches of the lower Fraser River extending from its seaward end at the Strait of Georgia to the head of tide water at Sumas, a distance of approximately 60 miles. Tributary Pitt River and Pitt Lake (30 square miles in area) are subject to tidal influence and are included in the model. Natural tides and river discharges can be synchronized and simulated on the model and are controlled

automatically by electronic servo-systems. Sand injection can be controlled automatically as a function of river discharge; however, manual injection has been found to be more satisfactory. Instantaneous water surface elevations can be obtained over the whole model by automatic, electrically-recording, point gauges situated at points where recording gauges are located in the prototype. Natural river sand of appropriate grain size is used for the bed material.

- (h) Progress Reports, Technical Notes, Project and Technical Reports submitted periodically to the Department of Public Works of Canada. Plans are being considered for moving the model to a new site on the campus.

(4448) NEW WESTMINSTER HARBOUR MODEL.

- (b) Hydraulic Model Studies cooperative with the Department of Public Works of Canada, Vancouver, B.C.
- (d) Experimental project to aid Federal Government engineers improve channel depths and navigation conditions generally, in the harbour of New Westminster, B.C.; by utilizing river-training structures combined with a minimum of dredging.
- (e) An outdoor, erodible-bed, tidal river model of New Westminster Harbour was incorporated in the tidal basin of the Fraser River Model. Horizontal scale 1:300, vertical scale 1:70. The model is contained in a rectangular basin measuring 70 feet by 36 feet. Some of the water pumped into the tidal basin of the Fraser River Model for the generation of tides was diverted through the New Westminster Harbour Model, while the tide-height control was obtained with the existing Fraser River Model equipment. The New Westminster Harbour Model was built to check the results of previous studies in the Fraser River Model where severe scale distortion precluded accurate details of scour around structures. It was also used to study requested modifications in the functional design of the structures evolved with the aid of the Fraser River Model.
- (g) In general, the behaviour of the two models was closely similar as regards shoaling and scouring of the bed, velocities, flow patterns, discharge distribution and stages. The smaller scale distortion in the New Westminster Harbour Model made it possible to observe shoal and scour with greater accuracy and certainty.
- (h) Reports and Memoranda submitted periodically to the Department of Public Works, Canada.

(4449) A STUDY OF GROINS AND THEIR FUNCTIONS AS HYDRAULIC STRUCTURES.

- (b) Hydraulic laboratory studies cooperative with the Department of Public Works of Canada, Vancouver, B.C.
- (d) Experimental project to check the results given by other investigators and to further explore the possibilities for utilizing groins as river-training structures.
- (e) Non-overflow, impermeable groin models were installed singly in a large concrete flume in the Hydraulic Laboratory. The test area in the flume was 25 feet long and 5 feet wide and the hydraulic conditions were accurately controlled. Tests with different flow velocities and depths and with various lengths of groins were conducted for both fixed and movable beds. The length of bank protected downstream from the groin was measured on the basis of flow patterns (for fixed beds) and scour (for movable beds). Different types of groin heads were also tested as well as the angle of orientation of the groins to the flow.
- (g) It was apparent from the limited studies made that there are many variables affecting the behaviour of groins under different conditions. The results of groin studies made in different countries showed a lack

of agreement.

- (h) A report on the first phase of the study was submitted to the Department of Public Works of Canada, Vancouver, B.C.

(4450) DEVELOPMENT OF DOW CHEMICAL OF CANADA LTD. ON TILBURY ISLAND, FRASER RIVER, B. C.

- (b) Hydraulic model studies cooperative with Dow Chemical of Canada Ltd. and the Department of Public Works of Canada, Vancouver, B.C.
- (d) Experimental project to determine the effect of river-side structures on the navigation channel in the Main Arm of the Fraser River. Also to determine a shoal-free location for a wharf and a pumping station which would supply cooling water from the Fraser River to the Chemical Plant. The wharf and pumping station were located on a small island offshore of Tilbury Island on the left bank of the Main Arm. The two islands were to be joined by a causeway composed of sand fill. This causeway would block the minor flow between the two islands. It was necessary as a result of these proposals to know the probable hydraulic and sediment conditions around the wharf and pumping station.
- (e) Models of the wharf, pumping station and causeway were built into the Fraser River Model. Flow patterns and bed configurations were observed around the small island. From these tests, supplemented by studies of earlier sounding maps of the area, it was possible to determine the best location and orientation of the wharf and pumping station on the small island and their distance out from the shore.
- (g) The causeway caused a concentration of flow around the upstream end of the small island, consequently rock protection there was recommended.
- (h) Reports were issued to the Department of Public Works of Canada and Dow Chemical of Canada Limited.

4451) HEAD LOSS IN SPHERICAL WYES.

- (b) Laboratory project.
- (c) Dr. E. Ruus, Dept. of Civil Engineering, University of British Columbia.
- (d) Applied research.
- (e) The spherical wye due to its small dimensions is particularly suitable as a wye-branch in large penstocks under high head. Railway clearances may impose the limit of the size of individual pieces to be shipped. A model is under construction to measure the head losses in the spherical wye and to find whether improvements could be made.

ECOLE POLYTECHNIQUE, Department of Civil Engineering, Hydrodynamics Laboratory.

Inquiries concerning the following projects should be addressed to Professor Raymond Boucher, Director, Hydrodynamics Laboratory, Ecole Polytechnique, 2500 Marie-Guyard Avenue, Montreal 26, Quebec, Canada.

(4043) STUDY OF THE RELIABILITY AND OPERATION OF BACK-WATER VALVES ON PLUMBING SYSTEMS AGAINST FLOODING BY PUBLIC SEWERS.

- (b) City of Montreal, City Planning Department, Inspection Division.
- (d) Experimental; applied research.
- (e) A full scale three-story plumbing system has been erected in the Hydrodynamics Laboratory of Ecole Polytechnique. The diameter of the pluvial column, the soil stack and the drain is 4 inches. The drain has many sections of pyrex glass to permit observations at critical points. A system of valves and of cross-connections on the vents lends to various combinations of tests. The back-water valves have a transparent

lucite cover to enable visual observations. As air entrainment seems to have a great importance on the venting capacity, the rate of air entrained in the vertical columns is measured at the inlet by means of a hot-wire air-meter. Various flooding conditions of the public sewers are simulated by a tank in which the water level can be controlled by gate valves. This research is aimed at determining whether back-water valves can offer home dwellers a reliable protection against flooding due to any overload of combined sewers. If this method is not satisfactory, an improved design of plumbing system may be suggested.

- (g) The mechanism of air entrainment has been studied and tests have revealed the best position for some of the vents.
- (h) Progress report in preparation.

(4044) HYDRAULIC AND MECHANICAL TESTING OF A 16-INCH BUTTERFLY VALVE.

- (b) Dominion Engineering Company Limited.
- (d) Experimental; for design.
- (e) Head losses to be measured across the Butterfly Valve as a function of valve opening for discharges from 500 to 10,000 U. S. gpm. Torque determination to be executed throughout opening and closing cycles by means of strain gage and electronic recorder at same flows as and concurrently with the head loss test, and at zero flow. An endurance test for 10,000 closing and opening cycles is also to be performed on the valve at a discharge of 10,000 U. S. gpm when the valve is fully open. Visual inspection for seat leakage is to be made after 100, 1000, 3,000, 5,000, 8,000 and 10,000 cycles.
- (f) Completed.
- (h) Report submitted to sponsor.

(4452) MODEL STUDY OF AN INVERTED SIPHON PROPOSED BY THE CITY OF LASALLE.

- (b) Lauriault & Villeneuve, Consulting Engineers, and the City of LaSalle.
- (d) Experimental; for design.
- (e) A lucite model of an inverted siphon was made to a scale of 1:15. Special inlet and outlet were studied, consisting of three bellmouth entrances to vertical pipes of the following diameters: 20-, 54-, and 126-inch. Means of eliminating the vortices were found and the head losses at entrance and outlet were measured. Head losses were also measured at the 90° elbows in all three pipes. The total head loss in the siphon was evaluated.
- (f) Completed.
- (h) Report submitted to sponsor.

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO, Hydraulic Model Laboratory.

Inquiries concerning the following projects should be addressed to Mr. J. B. Bryce, Hydraulic Engineer, Hydraulic Generation Department, 620 University Avenue, Toronto 2, Ontario, Canada.

(3324) ST. LAWRENCE RIVER MODEL - OGDENSBURG TO LEISHMAN'S POINT.

- (b) Ontario Hydro and the Power Authority of the State of New York.
- (d) Experimental; for design, development and operation.
- (e) A 1:500 x 1:100 scale model of St. Lawrence River between Ogdensburg and Leishman's Point, a distance of 16.1 miles, was constructed to determine the design of channel enlargements, the location of the Iroquois Control Dam and a plan of river control during construction of the St. Lawrence Power Project. The locations and conditions for a series of six ice booms for ice control were determined.
- (f) Work is essentially completed but model is

still active.

- (g) Channel enlargements were developed which met the criteria stipulated by the International Joint Commission with respect to navigation and ice-forming velocities and the seaway navigation channel was located. The optimum arrangements and location for the Iroquois Control Dam was determined. A plan of river control during construction was developed.

(3325) ST. LAWRENCE RIVER MODEL - OGDEN ISLAND REACH.

- (b) Ontario Hydro and the Power Authority of the State of New York.
- (d) Experimental; for design, development and operation.
- (e) A 1:500 x 1:100 scale model of the St. Lawrence River reproducing 7.9 miles of the river between the towns of Iroquois and Morrisburg, was constructed to determine the design of channel enlargements and a plan of river control during construction of the St. Lawrence Power Project.
- (f) Work is essentially completed but model is still active.
- (g) Channel enlargements were developed which met the ice-forming criteria stipulated by the International Joint Commission and a satisfactory Seaway Navigation channel was located. A plan of river control during construction was developed.

(3326) ST. LAWRENCE RIVER MODEL - DEWATERING AND CLOSURE AREA.

- (b) Ontario Hydro and the Power Authority of the State of New York.
- (d) Experimental; for design, development, and operation.
- (e) A 1:500 x 1:100 scale model of the St. Lawrence River reproducing 13.8 miles from Cat Island to below the powerhouses was constructed to develop plans for dewatering the Long Sault Dam and the powerhouse and to investigate conditions during the various stages of their construction.
- (f) Work is completed but model is still active.
- (g) Dewatering diversion channels were designed in detail and a plan of construction developed to preserve the necessary water levels for existing navigation and ensure adequate discharge capacity in the various stages of construction. Velocities in the Seaway Channel were also investigated. The Power Pool filling operation was investigated in detail.

(3333) ST. LAWRENCE RIVER MODEL - TAILRACE AREA.

- (b) Ontario Hydro and the Power Authority of the State of New York.
- (d) Experimental; for design.
- (e) A 1:160 x 1:80 scale model reproducing 2.5 miles of the St. Lawrence River from above the powerhouses to below Polly's Gut, has been constructed to develop the design of an economic tailrace improvement and a suitable dewatering scheme.
- (f) Work essentially completed but model is still active.
- (g) An economic tailrace enlargement was developed in the model. A cofferdamming plan to dewater much of the enlargement area was devised and the velocities at various stages observed. A plan for disposal of dredged material behind a dyke adjacent to the work area was developed.

(3335) RED ROCK GENERATING STATION MODEL.

- (b) Ontario Hydro.
- (d) Experimental; for design.
- (e) A 1:60 scale comprehensive model of the sluiceways, powerhouse and upstream and downstream river channel has been constructed to determine the dewatering arrangements for construction, velocities along cofferdams, energy

- dissipating works at the sluices, the rating of the diversion sluices, ports and sluiceways, the tailrace excavation, and location of log slide.
- (f) Work is completed and model removed.
 - (g) The dewatering plans were tested in the model and a plan for log driving past the side during construction was devised. The performance of the energy-dissipating works and the log chute was verified. Discharge calibrations for sluices and ports were obtained. Performance data for operational use was obtained.
- (3643) HEADGATE MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; as applied research.
 - (e) A 1:24 scale model of the St. Lawrence powerhouse headgate and inlet water passage was built to investigate the hydraulic forces on gates with upstream and downstream skin plates under conditions of horizontal and sloping floors and submerged and free discharge conditions.
 - (f) Work is essentially completed but model is still active.
 - (g) A series of curves was developed from which hydraulic downpull forces may be determined for several types of gates and gate installations for use in preliminary designs.
- (3644) OTTER RAPIDS GENERATING STATION MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; for design.
 - (e) A 1:72 scale comprehensive model of the sluiceways, powerhouse and upstream and downstream river channels has been constructed to determine the dewatering arrangement for construction, velocities at and along cofferdams, height location and slope of high water channel sluiceway training walls, the rating of the diversion ports and the sluiceways and the tailrace channel enlargement.
 - (f) Work is essentially completed but model is still active.
 - (g) The dewatering plans were developed and tested in the model. The calibration and performance of the four tunnel diversion ports for use during construction were determined. The design and operational use of the sluiceways in the high water channel were tested.
- (4023) DOUGLAS POINT INTAKE MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; hydraulic design and operation of water intake.
 - (e) A 1:24 model was constructed of the intake, tunnel and forebay of a nuclear generating station. The design of the intake to draw cooling and process water from a lake and to exclude floating ice and vortices as well as the forebay design of the pumping station and operation under pick-up and rejection of the pumping capacity.
 - (f) Testing completed and model removed.
 - (g) An intake of unusual design was developed which incorporates a thin concrete roof over a fan-shaped intake. The forebay design of the pumping plant was detailed and tested.
- (4024) ADAM CREEK CONTROL STRUCTURE MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; hydraulic design and operation
 - (e) A 1:60 model was constructed to determine the rollway profile and pressures, pier-shape, discharge capacity and energy-dissipating works with fixed and moveable bed.
 - (f) Testing completed and model removed.
 - (g) The rollway profile was determined and tested in conjunction with training walls and energy dissipating protection. Discharge calibrations were obtained as well as operational data.
- (4025) TRASH RACK LOSS STUDY.
- (b) Ontario Hydro.
 - (d) Experimental; basic research.
 - (e) A 1:12 model was constructed in a flume where hydraulic losses due to shape and number of horizontal members and shape and spacing of vertical members were determined. The effects of angularity to flow were also investigated.
 - (f) Testing completed and model removed.
 - (g) The complete series of tests determined the features contributing to the hydraulic losses from the various components under study.
- (4026) NIAGARA RIVER MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; for design and operation.
 - (e) An existing 1:250 x 1:50 scale model reproducing five miles of the Niagara River from Buckhorn Island to below the Cataracts is being used to determine the operational characteristics of the Niagara Control Structure under developed conditions. This model was previously used to investigate the remedial works necessary for the Preservation and Enhancement of Niagara Falls and for the location of the intakes and necessary river improvements of both Ontario Hydro and the Power Authority of the State of New York. To fully realize the terms of the 1950 Niagara Treaty, additional remedial works have been designed. These include a five-gate extension to the existing 13-gate control structure as well as a system containing an upstream accelerating wall, a downstream training wall and overflow weir for the safe passage of ice past the various intakes along the Canadian shore of the river above the Falls. The sequence of construction of these works and the conditions during their construction were determined in the model. Rating of the structure under cofferdammed conditions was obtained.
- (4453) LITTLE LONG GENERATING STATION INTAKE MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; for design.
 - (e) A 1:36 scale model of a bell-mouthed water passage from the dam to the circular penstock and scroll case was built. The configuration of the bell mouth was determined and the design of the bay-window type trash racks upstream of the dam face. Piezometer tap locations were investigated for future prototype Gibson test efficiency tests.
 - (f) Work is completed but model is still active.
- (4454) ONTARIO POWER GENERATING STATION - INTAKE AND WEIR MODEL.
- (b) Ontario Hydro.
 - (d) Experimental; for design and operation.
 - (e) A 1:50 scale model was built of the Ontario Power outer forebay intake wall and a portion of the downstream training wall and overflow weir, which are a part of the extension to the Niagara River additional remedial works. The design of the weir and wall as developed in the distorted Niagara Model was checked in this natural scale model.
 - (f) Work is completed but model is still active.
- (4455) ARROW LAKES DAM - COLUMBIA RIVER.
- (b) British Columbia Power Commission.
 - (d) Experimental; for design and operation.
 - (e) A 1:80 scale model of the Arrow Lakes and dam and environs is being built to determine the adequacy of the water passages in a concrete structure and the energy-dissipating works associated earth dam. A 1:50 scale model is being tested in a flume to determine the hydraulic design of the tunnel ports in the concrete structure and to develop the associated energy-dissipating works. Rating

- of these ports will be obtained as well as the hydraulic loadings of the port gates.
(f) Construction of the model has been initiated.

LASALLE HYDRAULIC LABORATORY LTD.

(3346) MODEL STUDY OF THE CARILLON POWER PROJECT.

- (b) Quebec Hydroelectric Commission.
- (c) Experimental; applied research.
- (e) General characteristics of the Carillon Power project will be completed during 1961 on a model scale 1/110. Tests on this model have been resumed in order to study the effects of the remaining part of a submerged cofferdam in expectation of a high Fall flood.
- (f) Completed.
- (h) Report submitted to sponsor.

(4028) CARILLON POWER PLANT - DOWNSTREAM WATER LEVEL FLUCTUATIONS DURING WINTER.

- (b) Quebec Hydroelectric Commission.
- (d) Theoretical; operation.
- (e) Study of the effects of the peak power plant operation on ice conditions and water level fluctuations in the Montreal Harbor, the Riviere des Prairies and the downstream part of the Ottawa River.
- (f) Completed.
- (h) Report submitted to sponsor.

(4034) MANICOUAGAN POWER PLANT SITE 5 TEMPORARY DIVERSION.

- (b) Quebec Hydroelectric Commission.
- (d) Theoretical and experimental; design.
- (e) A 1/108 scale model being used to determine the stage - discharge law of the two diversion tunnels proposed. Studies carried out so far include refinements of the intakes and outlets to improve conditions of transition from free surface flow to pressure flow in the tunnels. Law of upstream level vs. discharge takes into account considerable storage in reservoir formed by upstream cofferdam.
- (f) Completed.
- (h) Report submitted to sponsor.

(4035) MANICOUAGAN POWER PLANT SITE 5 - COFFERDAM.

- (b) Quebec Hydroelectric Commission.
- (d) Theoretical and experimental; design.
- (e) Study of the cofferdamming of the Manicouagan River by Toe Dumping method has been carried out on a 1/48 scale model. First stage prototype construction has confirmed results of the model.
- (f) Completed.
- (h) Report submitted to sponsor.

(4042) LAVIGNE PUMPING STATION.

- (b) City of Montreal.
- (d) Theoretical and experimental; design.
- (e) Hydraulic design of an automatic pumping station which drains a domestic and storm water sewer. Flow conditions and prevention of sedimentation have been studied on a scale model.
- (f) Completed.
- (h) Report submitted to sponsor.

(4456) VELOCITY AND DIRECTION OF CURRENT RECORDER.

- (b) Laboratory project.
- (d) Experimental; development of instrument for hydrographic and oceanographic research for acquisition of datum in computable form (punched tape) for fast decoding and calculation.
- (e) Recording of velocity by impulse counter for propeller type current-meter. Recording of direction by reading an encoder monitored by a marine compass. Instrument must be:

(1) Rugged; (2) simple and easy to maintain (only electromechanical); and (3) very low power drain for long periods (recording up to 6 months under ice).

- (g) Prototype routine tests equivalent to 2 years without failure have been carried out. Tests at sea expected to be carried out in Spring 1962; autonomy 4 to 8 months. Depth up to 2000 feet.

(4457) WATER LEVEL TELEREORDER.

- (b) Laboratory project.
- (d) Experimental. Development of telereorder for water level measurements in silty and dirty waters (mainly sewers). No movable parts in the transducer. No electric supply at measurement point. Multi-channel.
- (e) Auto compensated resistance bridge--automatic graphical and punched tape recording. Telecommunication of different transducers.
- (f) Completed.
- (g) Teletransmission up to 15 miles within a 0.5% accuracy.

(4458) PEACE RIVER - PORTAGE MOUNTAIN DEVELOPMENT.

- (b) British Columbia Electric and I.P.E.C.
- (d) Theoretical and experimental; design.
- (e) A 1/100 scale model was constructed to determine the practicability of the hydraulic design of the three diversion tunnels proposed. Studies include: approach channel, intake tunnels, discharge capacity, energy dissipating works with movable bed and cofferdamming of the river.

(4459) DUNCAN LAKE PROJECT.

- (b) Montreal Engineering and B.C.P.C.
- (d) Experimental; design.
- (e) A 1/48 scale model used to study the best design of the outlet works for the diversion tunnels and of the downstream discharge channel in order to minimize erosion, ensure stability of the structures and prevent deposition of material near the tailrace of the powerhouse.

(4460) FORMATION AND EVOLUTION OF ICE-COVERS OF RIVERS.

- (b) Laboratory study
- (d) Basic research.
- (e) Research of the basic laws governing the formation of ice covers on river.
- (g) Result of this research seems to agree with nature measurements and explains several phenomena.
- (h) Publication in ESME - EIC Congress 1961 in Montreal.

(4461) ST. PAUL AUTOMATIC SEWAGE REGULATOR.

- (a) City of Montreal.
- (d) Theoretical; design.
- (e) Study of the maximum curing discharge to be introduced at all times in this collector which would be compatible with its flow conditions. The solution under study consists of an automatic sewage regulator with downstream control.
- (g) A special device has been designed for measurements of sluicy and storm waters.

(4462) THE ST. PIERRE SEWAGE COLLECTORS FLOW METER.

- (b) City of Montreal.
- (d) Theoretical; design.
- (e) Study of the maximum curing discharge to be introduced at all times in this collector which would be compatible with its flow conditions. The solution under study consists of an automatic sewage regulator with downstream control.

(4463) PEACE RIVER - PORTAGE MOUNTAIN DEVELOPMENT.

- (b) British Columbia Electric and I.P.E.C.
- (d) Theoretical; design.
- (e) Preliminary study of the design and the air requirements of the low level outlets which will be installed in two diversion tunnels. A more elaborate study will be carried out on a scale model.

NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering.

Inquiries concerning the following projects should be addressed to Dr. D. C. MacPhail, Director, Division of Mechanical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, Canada.

(4047) BAIE COMEAU, PROVINCE OF QUEBEC.

- (b) Department of Public Works, Canada.
- (d) Experimental; for design.
- (e) This harbor is located on the north shore of the Gulf of St. Lawrence where it is subject to fairly strong wave action. Extensions to the harbor were required which would provide safe berthing areas for ships. As a result of tests on a 1/100 scale model, a layout incorporating a 100-foot extension to an existing pier was adopted. A new design of perforated vertical wall breakwater which reduces wave reflection, was developed for this project.
- (f) Project completed.
- (g) Design data have been issued to the sponsor. The perforated wall breakwater has shown considerable promise as a means of reducing wave reflection and scouring at the foundation.
- (h) "A Perforated Vertical-Wall Breakwater," by G. E. Jarlan, Dock and Harbor Authority, Vol. XLI, No. 486, April 1961.

(4048) NORTHUMBERLAND STRAIT CAUSEWAY.

- (b) Department of Public Works, Canada.
- (d) Experimental; for design data.
- (e) A rubble-mound causeway has been proposed to link Prince Edward Island with the mainland, a distance of 9-1/2 miles. Because of the exposed location, and the prevalence of large quantities of ice, it is essential that the structure have adequate stability to resist damage. A 1/30 scale model of a typical cross-section as designed by the consulting engineers, and later modified, was tested in a wave flume under simulated prototype conditions.
- (f) Suspended.
- (g) A design has been obtained which will resist the waves likely to occur at the side.
- (h) A report has been issued to the sponsor.

(4050) STUDY OF ICE DRIFT.

- (b) Laboratory project.
- (d) Theoretical study.
- (e) A study of the drift of ice in the Gulf of St. Lawrence has been conducted.
- (f) Completed.
- (g) The mechanics of wind-induced currents and meteorological records have been studied and it has been concluded that a permanent cyclonic circulation occurs in the Gulf. The study indicated a possible theoretical route which could be used by ships during the winter.
- (h) "Note on the Wind-Induced Upper Layer Circulation and Subsequent Ice-Drift Phenomena in the Gulf of St. Lawrence," by G. E. Jarlan, ASME-ETC Hydraulics Conference Paper No. 61-EIC-15, Trans. E.I.C., Vol. 5, No. 2, 1961.

(4051) LOCK-FILLING MANIFOLD ANALYSIS.

- (b) Laboratory project.
- (d) Theoretical and experimental; applied research.
- (e) An analysis of multiple port culvert systems for navigation locks has been made in an attempt to study lock behavior without using large models. An approximate solution to a

network of lumped impedances, using experimentally determined coefficients, has given results which are in good agreement with experimental data. The study is continuing, using a 1/12 scale model of a small navigation lock as a source of experimental data. A detailed experimental study to determine head loss parameters associated with flow in a port manifold is nearing completion. A report will be prepared on completion of the project.

(h)

(4464) RUSTICO HARBOUR, PRINCE EDWARD ISLAND.

- (b) Department of Public Works, Canada.
- (d) Experimental; for design.
- (e) This harbour is located in an area of strong littoral drift and as a result the entrance is subject to shoaling. In addition, the width of the entrance is variable. A high-way bridge across the entrance to the harbour has been proposed but before design work can be started some means of stabilizing the width of the entrance must be obtained. To study the problem a model to scale of 1:150 by 1:30 is being constructed. Crushed bakkelite will be used as a movable bed material.
- (g) Tests not yet started.

(4465) SPILLWAY.

- (b) Shawinigan Engineering Company, Limited.
- (d) Experimental; for design data.
- (e) Tests are being made on a model of a side channel spillway designed to pass flood water about a proposed power plant. Because of rock conditions, a conventional spillway cannot be used. A 1/60 scale model has been constructed to study flow conditions in the spillway and downstream of the power house.
- (h) A report will be issued to the sponsor when the project is complete.

(4466) AIR BUBBLERS.

- (b) Laboratory project.
- (d) Experimental; field investigations.
- (e) Preliminary experiments have been made to determine the effectiveness of various proposed air bubbler systems for melting ice. Temperature surveys in lakes and rivers, and temperature-salinity surveys in the sea and in estuaries have been made to explain and/or predict the success or failure of such installations.
- (h) "Recent Experimental Observations on the Use of Air Bubbling Systems," has been presented to a Symposium on Air Bubbling Systems organized by the Division of Building Research, National Research Council.

ONTARIO AGRICULTURAL COLLEGE.

(2492) RUNOFF FROM SMALL WATERSHEDS.

- (b) Laboratory project.
- (c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Experimental; applied research.
- (e) The relationship of precipitation and snow-melt to runoff characteristics on four watersheds of 20 acres each, under various land use practices, is being evaluated.
- (g) Winter surface runoff from watersheds with good grass-legume cover is greater than from watersheds plowed during the winter season.

(2740) MAIN TILE DRAIN SIZES FOR COMPOSITE DRAINAGE OF BROOKSTON CLAY SOIL.

- (b) Laboratory project.
- (c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; applied research.
- (e) Discharge measurements from lateral tile drains in Brookston clay soil are being made to determine the proper drainage coefficient

to use in the design of main tile drains and to determine the effect of lateral tile drain spacing on the drainage rate. Two additional lateral drains were installed in the fall of 1960.

- (g) The collection of data is being continued.

(3363) HYDROLOGIC CHARACTERISTICS OF ORGANIC SOIL.

- (b) Laboratory project.
- (c) Prof. R. W. Irwin, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; applied research.
- (e) The study is being carried out to establish criteria to be used in the development and operation of a water control program for organic soils. In the investigation, an attempt will be made to establish a hydrologic water balance for the field area by measuring, recording, and analyzing so far as possible the evaporation, seepage, transpiration, precipitation, water table elevation and ground water discharge through tile drains.
- (g) Data are presently being analyzed.

(3658) THE RESISTIVITY METHOD FOR GROUND WATER EXPLORATION.

- (b) Laboratory project.
- (c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; applied research.
- (e) The objective is to investigate the application of the resistivity method to subsurface exploration for ground water under the geological conditions found in southern Ontario.
- (g) A lateral investigation to find a buried pre-glacial river bed in the bedrock surface is completed. A graduate thesis is being prepared.
- (h) "Electrical Ground Water Prospecting," by D. F. Witherspoon, Agric. Eng. 42:134-135, 138, March 1961.

(3660) RAINFALL DEPTH-AREA-INTENSITY RELATIONSHIPS IN CENTRAL ONTARIO.

- (b) Laboratory project.
- (c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; applied research.
- (e) A dense network of standard and recording rain gages has been established in the Guelph area with the cooperation of the Meteorological Branch, Department of Transport. The network is over an area of approximately 12 square miles with an average gage density of 1 per square mile. The purpose of this study is to obtain detailed information on summer precipitation characteristics for use in the hydrologic design for small drainage basins.
- (g) Three years data have been collected. Summer thunder storms show a highly variable areal distribution. One storm over the network varied from 4.53 inches to 0.02 inches depth.

(3661) HYDROLOGIC FACTORS AFFECTING BRIDGE DESIGN.

- (b) Laboratory project in cooperation with Ontario Department of Highways and University of Toronto.
- (c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Experimental; master's thesis.
- (e) The purpose of this project is to develop satisfactory design criteria for bridges and culverts based on watershed runoff relationships for Ontario. Frequency analyses of existing stream flow data for the province have been carried out. An attempt is being made to correlate watershed characteristics with peak discharge relationships.
- (f) Completed.
- (g) Regression equations for the prediction of peak discharges at various frequencies were developed in terms of watershed area, storage

factor, average watershed slope, and stream density. Deviations of "Formulae Flows" from "Statistical Flows" were about 25% at the 2.5% exclusion limits.

- (h) "Development of Empirical Formulae for Flood Flows on Southern Ontario Streams," by E. Karuks, M. A. Sc. thesis on file in Department of Civil Engineering library, University of Toronto.

(3662) POTENTIAL EVAPOTRANSPIRATION AND CONSUMPTIVE USE OF WATER BY CROPS.

- (b) Laboratory project.
- (c) Dr. K. M. King, Department of Soils, Ontario Agricultural College, Guelph, Ontario, Can.
- (d) Field investigations; basic research.
- (e) The purpose of this investigation is to evaluate the factors influencing evapotranspiration by the use of a specially designed floating lysimeter. Study is being conducted on the effect of soil moisture on the heat budget and evapotranspiration for crops.
- (g) Data analysis is continuing.
- (h) "Fraction of Net Radiation Utilized in Evapotranspiration from a Corn Crop," by W. G. Graham and K. M. King, Proc. Soil Sci. Soc. of America 25:158-160, 1961.
- "Short-Wave Reflection Coefficient for a Field of Maize," by W. G. Graham and K. M. King, Q. Jour. Royal Met. Soc. 86:425-428, 1961.
- "Evaporation from Land Surfaces," by K. M. King, Proc. 2nd Can. Hydrology Sym. The Committee on Geod. and Geophy., N. R. C., March 1961, Toronto.

(4052) COVER MATERIALS FOR TILE DRAINS.

- (b) Laboratory project.
- (c) Prof. F. R. Hore, Ontario Agricultural College Guelph, Ontario, Canada.
- (d) Experimental and field investigation; applied research.
- (e) This study is being made to determine the effect of several cover materials on soil movement and water discharged into a tile drain. Laboratory studies of some relatively new glass fiber materials have been completed and a field experiment based on those results was installed in the fall of 1960.
- (g) One set of sediment samples was collected from the field experiment in the spring, 1961 but no conclusions can be drawn as yet.

(4053) THE WATER YIELD OF SWAMP AREAS.

- (b) Laboratory project.
- (c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; Master's thesis.
- (e) A watershed of approximately 900 acres containing a swamp area is being studied to determine the relationship between watershed characteristics and water yield.
- (g) Analysis has been made of one year's data.
- (h) "The Hydrology of a Swamp Near Guelph, Ontario," by R. Prasad, M.S.A. thesis on file in Massey Library, Ontario Agricultural College.

(4054) RUNOFF FROM FLAT LAND.

- (b) Laboratory project in cooperation with Water Resources Division, Department of Northern Affairs and National Resources.
- (c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; applied research.
- (e) Several 2 to 10 square mile flat watersheds of fine-textured soils are to be studied to determine the relationship between precipitation, snowmelt, watershed characteristics and runoff. Hydrologic data on this type of watershed is being sought for the establishment of criteria for the design of hydraulic structures. The installation of gaging stations and the survey of watershed boundaries is continuing.

(4055) EVAPORATION FROM A SNOW SURFACE.

- (b) Laboratory project.
- (c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Field investigation; applied research.
- (e) Snow evaporation will be measured from a floating lysimeter and basic equations for the heat budget over a snow surface will be developed for estimating snow evaporation and snowmelt. These data will be used in a water balance for experimental watersheds in the Guelph area.
- (g) Equipment has been designed and constructed. Data will be collected during 1961-62.

(4467) DRAIN FLOW STUDIES.

- (b) Laboratory project.
- (c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
- (d) Experimental; basic research and development.
- (e) The object of this research is to study the fundamental nature of flow through multiple openings in an underdrain with the view towards development of satisfactory design criteria for the openings. A review of literature has commenced.

QUEEN'S UNIVERSITY AT KINGSTON, Hydraulic Laboratories.

(3364) LITTORAL DRIFT AND ITS EFFECT ON THE HARBOURS ON THE NORTH SHORE OF LAKE ONTARIO.

- (b) The National Research Council of Canada.
- (c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ontario, Canada.
- (d) Experimental and field; basic and applied.
- (e) Field and laboratory: 3-dimensional model of Cobourg Harbour.
- (h) "A Field Investigation of Littoral Drift in the Port Hope - Cobourg Area of Lake Ontario," by P. Donnelly and A. Brebner, Queen's Civil Engineering Report No. 16.
"A Model Investigation of Cobourg Harbour," by B. Le Mehaute and J. I. Collins, Queen's Civil Engineering Report No. 17.
"Wind and Waves at Cobourg, Lake Ontario," by A. Brebner and B. Le Mehaute, Queen's Civil Engineering Report No. 19. (Available from (c).)

(3603) THE CAUSE, GROWTH AND EFFECT OF SECONDARY CURRENTS IN STRAIGHT OPEN CHANNEL FLOW.

- (b) Laboratory project.
- (c) Professor R. J. Kennedy.
- (d) Theoretical investigation.
- (f) Discontinued.
- (h) "The Effect of Secondary Currents upon the Capacity of a Straight Open Channel," by R. J. Kennedy and J. F. Fulton, Trans., Eng. Institute of Canada, Vol. 5, No. 1, 1961.

(3666) CRITICAL MASS-TRANSPORT VELOCITIES FOR PARTICLES OF VARIOUS SIZES.

- (b) The National Research Council of Canada.
- (c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ontario, Canada.
- (d) Experimental laboratory investigation for doctoral thesis by J. I. Collins.
- (e) Work extended in an attempt to uncover relationships for superposed currents on mass transport characteristics.
- (h) "The Effect on Mass-Transport of the Onset of Turbulence at the Bed Under Periodic Gravity Waves," by A. Brebner and J. I. Collins, Trans. Engineering Institute of Canada, Vol. 5, No. 1, 1961.

(4056) SUBMERGED BREAKWATERS AS A SOLUTION TO HARBOUR DEPOSITION.

- (b) The National Research Council of Canada.

(c) Dr. B. Le Mehaute, Queen's Univ., Kingston, Ontario, Canada.

(f) Inactive.

(h) "The Use of Wave Energy to Reduce Silt Deposition in a Harbour," by B. Le Mehaute and J. Cowley, Trans. Eng. Institute of Canada, Vol. 5, No. 1, 1961.

(4057) THE TRANSPORT OF LOGS OR SUSPENDED SOLIDS THROUGH PIPELINES.

- (b) The National Research Council of Canada.
- (c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ont., Canada.
- (d) Laboratory investigation but to almost full-size scale.
- (g) Results with whole logs not encouraging. Work being commenced on pulp-wood chips of varying concentrations.

(4059) AGITATION IN A HARBOUR.

- (c) Dr. B. Le Mehaute, Queen's Univ., Kingston, Ont., Canada.
- (f) Discontinued.
- (h) "Theory of Wave Agitation in a Harbour," by B. Le Mehaute, Proc. A. S. C. E., Hydraulic Division, March 1961.

(4468) CRITERIA FOR THE INCIDENCE OF TURBULENCE.

- (b) National Research Council.
- (c) Prof. R. J. Kennedy, Queen's Univ., Kingston, Ont., Canada.
- (d) Basic research.
- (e) An apparatus to produce plane Couette flow is used. Both shear intensity and distance between boundaries are independently variable.

UNIVERSITY OF TORONTO, Department of Mechanical Engineering.

(1298) DISCHARGE CHARACTERISTICS OF WEIR-TYPE SPILLWAYS.

- (b) Laboratory project.
- (c) Prof. L. E. Jones, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for master's theses.
- (e) A long-term research carried out with a view to systematizing discharge characteristics for spillways having various pier spacings and proportions.
- (f) A computer project is being undertaken to review all numerical work and to utilize appropriate statistical procedures in the function-fitting.
- (g) Significant correlations obtained via special plotting techniques.
- (h) Report in preparation.

(3003) ROUGHNESS PHENOMENA IN OPEN CHANNEL FLOW.

- (b) Laboratory project.
- (c) Prof. L. E. Jones, University of Toronto, Toronto 5, Canada.
- (d) Experimental and analytical; basic research for doctoral thesis.
- (e) Critical analysis of the hydraulic radius concept and the effect of cross-section geometry on the resistance to flow in conduits. Detailed evaluation of mean flow parameters such as friction coefficients, static pressures, velocities, and wall shear stresses. The channel under study was 70 feet long and had a variable rectangular cross-section of 3 x 1, 3, 9 inches, respectively, and used air as the fluid medium.
- (f) First project completed.
- (g) Friction coefficients plotted as function of bulk Reynolds number exhibit a trend similar to but not identical with the circular pipe resistance law. The local velocities correlate well in the form of the inner law provided the local shear velocity is used. The appropriate velocity scale for the outer

law correlation is the average shear velocity, but this correlation is not established for Reynolds numbers below 10^5 . Static pressures increase toward the center of the ducts.

(h) Publication pending by A.S.C.E.

(3368) DIFFUSION OF GASEOUS PLUMES.

- (b) Laboratory project.
- (c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.
- (d) Experimental and analytical; basic research for doctoral thesis.
- (e) A jet of air is injected at right angles to a uniform flow. Mean velocities and turbulence parameters have been determined for a range of jet to flow velocity ratios.
- (g) Measured mean flow and turbulence parameters are being compared to a similarity analysis. Bulk characteristics of the jet are being derived. A general description has been obtained and it is hoped that prediction of very large scale jets can be made.
- (h) Report in preparation.

(4063) STACK HEIGHT DETERMINATION.

- (b) Canada Iron Foundries, Limited, Toronto.
- (c) Prof. G. Ross Lord, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for design.
- (e) Model study of low speed wind tunnel of stack discharge from existing foundry cupola under various conditions of velocity, wind, and stack height, to provide design data to reduce present incidence of downwash in dense industrial area.
- (f) Completed.
- (h) Reported to sponsor.

(4064) EFFECT OF GROINS ON LITTORAL TRANSPORT.

- (b) Laboratory project.
- (c) Prof. G. Ross Lord, University of Toronto, Toronto 5, Canada.
- (d) Experimental and analytical; applied research for master's thesis.
- (e) The motions of individual sediment particles of various sizes and densities were studied on a solid plane beach of 1:10 slope at 45 to the wave direction. Direction and magnitude of the particle velocities and the effect of groins upon particle motion were studied.
- (g) Wave induced currents have been analyzed and compared with experimental results. After minimizing the effects of nearshore circulation, equations are derived for littoral transport velocities of spherical particles for the given beach and wave configuration. Modification of existing refraction theories is proposed.
- (h) Report in preparation.

(4065) FLOW AROUND OBJECTS IMMERSED IN A BOUNDARY LAYER.

- (b) Laboratory project with assistance of Division of Building Research, National Research Council, Ottawa.
- (c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for master's theses.
- (e) An artificially thickened boundary layer has been produced on the floor of a wind tunnel. Pressure distributions and flow patterns are being measured for cubes, plates, and shapes typical of buildings.
- (g) Good agreement has been found between a simple theory and the measured pressure distributions for slender objects similar to tall buildings. Second order effects have been observed on

wide walls and on a cube, which indicate that strong pressure gradients must exist upstream of an object due to its presence in the fluid stream.

(h) Report in preparation.

(4469) DIFFUSION OF MOMENTUM AND ENERGY IN NON-CIRCULAR DUCTS.

- (b) Laboratory project.
- (c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.
- (d) Experimental and analytical; basic research for doctoral thesis.
- (e) Secondary currents and the rates of lateral diffusion and convection of mean flow and turbulent energy have been determined in a square duct. It is planned to study in detail the relative roles of turbulence and secondary currents and to investigate other flow characteristics and other duct shapes.
- (g) Secondary flows in the square conduit have been found to consist of 8 symmetrical vortices with flow directed into the corners. The maximum velocity is about 3% of the longitudinal mean velocity. These currents play a dominant role in the lateral transport of mean flow energy.

(4470) CHARACTERISTICS OF TURBULENT WALL JETS.

- (b) Laboratory project.
- (c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for master's thesis.
- (e) An apparatus has been constructed to produce a uniform two-dimensional wall jet. It is planned to study the mean flow and turbulence fields and the similarity of velocity profiles, with applications to heat and mass transfer.

(4471) WIND-INDUCED CURRENTS IN SHALLOW WATER.

- (b) Laboratory project.
- (c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for master's thesis.
- (e) Water currents in a long flume have been measured for the steady uniform flow of air above it. Three cases have been studied: constant depth, shoaling depth, and reduced width.
- (g) Velocity profiles appear similar for all cases. The turbulence level over most of the field is of the same order of magnitude as the mean flow velocities.
- (h) Report in preparation.

(4472) SURGES IN AIR VENTS.

- (b) Laboratory project.
- (c) Prof. L. E. Jones, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for master's thesis.
- (e) Investigation of mixed regime conditions due to sudden discharge changes in a horizontal conduit equipped with air vent and surge tank.

(4473) OUTLET STRUCTURE OF PROPOSED WILDWOOD DAM NEAR ST. MARYS, ONTARIO.

- (b) M. M. Dillon and Co., London, Canada, for Upper Thames River Conservation Authority, London, Canada.
- (c) Prof. G. Ross Lord, University of Toronto, Toronto 5, Canada.
- (d) Experimental; applied research for design.
- (e) Model investigation of optimum discharge capacity and energy dissipation. Evaluation of scouring tendencies at toe of dam.

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